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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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IMPORTANT NOTICE TO ALL ENGINEERING FIRMS ENGAGED ON MUNITION WORK.

Institute of Ophthalmic OPTICIANS.

President: The Rt. Hon. LORD ALDENHAM, M.A.

The attention of all engineering and manufacturing firms engaged on important Munition work, and especially those firms employing a large number of female workers, is directed to the following statement appearing in Memorandum No. 18, entitled, "The Effect of Industrial Conditions upon Eyesight," and issued by the Health of Munition Workers' Committee appointed by the Ministry of Munitions:—

"NOTWITHSTANDING THE IMPORTANT BEARING WHICH GOOD EYESIGHT MUST HAVE UPON OUTPUT, THE QUESTION IS NOT TO-DAY RECEIVING ATTENTION AT THE HANDS OF THOSE WHOSE DUTY IT IS TO OBTAIN THIS OUTPUT."—(Par. 5).

The Institute of Ophthalmic Opticians has, thanks to the patriotic voluntary enrolment of a large number of its members, been able to formulate an Industrial Sight-Testing Scheme, under which it undertakes to provide (voluntarily) qualified Opticians to test the eyesight of factory workers.

N.B.—A qualified Optician is understood to be an ophthalmic optician who has passed either the Sight-Testing Examination of the Spectaclemakers' Company whose examinations are under the direction of the Rt. Hon. Sir Wm. Hart-Dyke, M.A., and among whose examiners are Mr. H. G. Critchley, M.A., M.D., and other medical men and scientists, or that of the British Optical Association, whose examiners are R. S. Clay, D.Sc., Edwin Edser, A.R.C.S., W. J. M. Stiles, M.D., F.R.C.S., W. W. Haldane Gee, B.Sc., Albert Griffiths, D.Sc., W. J. May, F.R.G.S.

Firms desiring full details of this important scheme are requested to write to

Mr. J. HARCOMBE CUFF,
Secretary,
Institute of Ophthalmic Opticians,
25, Priern Barnet Road, London, N. 11.

J 420

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Tuition in separate subjects, if desired. Thorough, rapid, efficient coaching under my personal supervision.

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J 354

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0·75 square inch	...	1,500 yards.
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For Schedule of Lengths, Conditions of Sale and Tender Form, apply Borough Electrical Engineer, Frederick Road, Salford. J 392

L. C. EVANS,
Town Clerk.

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

COPPER TUBES,
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Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

Tenders must be delivered in separate envelopes sealed and addressed to the undersigned, marked "Tender for Copper Tubes," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 27th November, 1917.

The Directors do not bind themselves to accept the lowest, or any, Tender.

R. H. WALPOLE,
Company's Offices, Secretary.
48, Copthall Avenue, London, E.C.
14th November, 1917. J 470

APPOINTMENTS OPEN.

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EDUCATION COMMITTEE.

JUNIOR TECHNICAL SCHOOL, WALTON AND KIRKDALE TECHNICAL INSTITUTE, CARISBROOKE ROAD.

A Head Master is Required

for the Junior Technical School to act also as Superintendent of the Evening Technical Classes held in the same building. The person appointed will be required to devote the whole of his time to the service of the Committee. He must hold good mathematical and scientific or technological qualifications. Commencing salary at the rate of £300 per annum; the engagement will be determinable by three months' notice.—Applications, giving particulars of age, educational training, teaching and workshop experience, etc., with references and copies of recent testimonials, to be sent to the DIRECTOR OF EDUCATION, Education Offices, Sir Thomas Street, Liverpool, not later than Thursday, 22nd November, 1917. J 345

H. R. PICKMERE,
Town Clerk.

MONTGOMERY COUNTY COUNCIL.

Applications are Invited for

the POST of COUNTY SURVEYOR for the County of Montgomery.

Commencing salary £400 per annum, rising by annual increments of £35 to £500, if work considered satisfactory by the Council, together with a travelling allowance of £100 per annum and a free first-class railway pass in the county. An office and clerk will be also provided at the expense of the Council.

Applicants must be members of the Institute of Civil Engineers and qualified architects, and devote their whole time to the work of the Council.

A printed list of the duties of the Office can be had on application accompanied by a prepaid foolscap envelope.

Duties to commence as soon as possible after appointment, and applications to be sent in to the undersigned together with not more than three copies of recent testimonials, by not later than the 10th December next.

Candidates canvassing directly or indirectly will be disqualified.

GEORGE R. D. HARRISON,
Welshpool, Clerk of the Council.
13th November, 1917. J 463

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Wanted, a Manager and Engineer

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The person appointed will be required to devote the whole of his time to the duties, and in addition to taking charge of the manufacturing department will have the superintendence of the laying of mains, the services, the public lamps, and the distribution of gas and water. Applicants with experience in Electrical Engineering preferred.

Applications, stating age, qualifications, and previous employment, with not more than three recent testimonials, to be sent to me not later than the 27th November, inst., endorsed "Manager."

Canvassing strictly prohibited.

Dated this 14th day of November, 1917. J 432

W. PERCIVAL JONES,
Town Clerk.

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DISTRICT ELECTRICAL ENGINEER,
40, Forest Road West, J 466
Nottingham

Wanted, for a Large Marine

Engineering establishment, HEAD CLERK. Must be thoroughly experienced, also capable correspondent. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4010 and ENGINEERING. J 403

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WANTED, for Controlled Establishment, North-West London District. Good opening and permanent position for a man possessing good all-round engineering knowledge. Applicants should have received a thorough training in systematic and efficient factory organization. No persons more than 10 miles away or engaged on Government work need apply.—Write, stating qualifications and salary, to J 270, Offices of ENGINEERING.

Wanted, for Controlled

Establishment, North-West London District, ASSISTANT WORKS MANAGER or SUPERINTENDENT, for taking entire control of about 1000 workpeople, male and female. The position will be a permanent one, and offers considerable scope for an engineer who is a systematic and capable organiser and has had experience in a somewhat similar position. No persons more than 10 miles away or engaged on Government work need apply.—Write, stating qualifications and salary required, to J 269, Offices of ENGINEERING.

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ENGINEER and WORKS MANAGER WANTED, to take sole charge of big 6ft Mills. Only gentlemen with thorough theoretical training, practical factory experience and excellent testimonials, are invited to address, J 423, Offices of ENGINEERING.

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qualifications, thorough knowledge and experience of computing by logarithmic tables and all-in rules from given formulæ; also plotting graphs of functions.—Apply by letter, BOX No. 1269, care of Messrs. R. F. WHITE & SON, General Advertising Agents, 33, Fleet Street, E.C. 4, stating qualifications and previous experience. Women, and men unfit or otherwise exempt from military service only. J 415

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Factory in the North. Must have sound previous experience in similar capacity, and thorough knowledge of markets and materials.—Applications, with full details of qualifications, salary required, when at liberty, &c., should be made to nearest EMPLOYMENT EXCHANGE, quoting this Journal and J 323.

Required, in Government

Factory, for work in connection with Aeroplanes and Aeroplane Engines, several YOUNG MEN with scientific engineering training. Previous experience of aeroplanes not essential. Men already on Government work need not apply.—Send full details of experience and salary required to your nearest EMPLOYMENT EXCHANGE and quote reference number A 3849. J 163

Wanted, Technical Assistant

for Power Plant Work; age about 23.—Applications, stating age, qualifications, experience and salary required, accompanied by copies of testimonials, should be addressed to J 241, Offices of ENGINEERING.

Assistant Required for Purchasing

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FITTER. Must have thorough knowledge of Premium Bonus System in connection with aeroplane and motor engine parts. No one already on Government work will be engaged.—State experience and wages required to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 404.

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in coke oven plant, coal-handling machinery, and chemical or tar plants WANTED Immediately.—Apply, stating experience, age, and salary required, to KOPPERS' COKE OVEN AND BY-PRODUCT CO., 301, Glossop Road, Sheffield. No one already employed on Government work will be engaged. J 348

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Draughtsmen for Electrical

machines and control gear, steam turbines and steam layouts.—Applicants must have good mechanical knowledge, and should send full particulars including age and salary required to their nearest EMPLOYMENT EXCHANGE, mentioning this Journal and A 4029. J 427

Draughtsman Wanted for

London engineering works, some knowledge of chemical plant preferred. No one engaged on Government work or residing more than 10 miles away need apply.—Write, stating age, experience, and salary required to J 362, Offices of ENGINEERING.

Two Draughtsmen Required

for blast furnace and steel works plant extension in Lincolnshire. State age, experience and salary required. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and A 3997. J 337

Wanted, One or Two First-

class DRAUGHTSMEN, thoroughly experienced in high class instruments design, for important Government work.—Address, giving full particulars of qualifications, stating wage required and when at liberty, J 444, Offices of ENGINEERING.

Wanted for the London Office

of a large manufacturing concern, DRAUGHTSMAN with electrical and general experience and accustomed to the lay-out of plant. Knowledge of heavy grinding machinery an advantage. No one at present on Government work will be engaged.—Write, BOX 430, WILLINGS, 125, Strand, W.C. 2. J 448

Wanted, Mechanical

DRAUGHTSMAN, used to Boiler practice, Newark-on-Trent district. No one already on Government work will be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 408.

Wanted, Draughtsman for

the mechanical design of large electrical direct current machines. Nobody engaged on Government work will be accepted.—Write or apply to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2631. G 457

Wanted, Draughtsmen, with

experience of Automobiles and Aeroplanes; also Jig and Tool Draughtsmen. Good money to right men. London, N.W. State age, experience and salary expected. No one residing more than ten miles away or already engaged on Government work need apply.—Address, J 431, Offices of ENGINEERING.

THE ARRANGEMENT OF MACHINE SHOPS.—No. XXI.

By Joseph Horner.

The supply of the lubricating and cooling media to the cutting tools, and its recovery and purification involves the installation of a large plant in those shops where the system is carried out with the intention of achieving high efficiency. This includes details which are extraneous to the machines, and also those which are included in their design. The first group comprise pumps, pipe systems, means of distribution, collecting trays, chip baskets, settling tanks, centrifugal separators, the warming by steam, sterilization, and magnets—though all these adjuncts are not necessarily included in a single plant. The second group concerns certain embodiments of design in the machines, such as collecting trays, tanks, and strainers; as well as pumps, protective arrangements to bearings and slides. The importance of these systems is now so generally recognised, and their details tend to become so technical that several engineering firms specialise wholly in this branch, and supply equipments of lubricating plant to machine shops. Machine makers commonly include in their designs specific provisions for the supply and collection of lubricant.

In most shops the provision for the lubrication of each machine is still made independently of that of others, but in very many of the newly-built factories the machines are connected to a system of supply pipes, and to an overflow drainage common to all. This drainage system consists of pipes placed in channels underneath the floor, the collected lubricant after having been subjected to suitable treatment being pumped to its storage in an overhead tank for another cycle of service. The screw machines and turret lathes gave the first great impetus to this system, which is now largely provided for other groups of machine tools.

The fact is also now being largely realised that the individual characteristics of unlike machines should be accorded special provisions suitable to their wants. In order to secure this, their equipments and details of service must be treated individually. The larger the quality of heat generated, the more copious ought the volume of coolant to be, and this can be provided by pumps of suitable capacities. The products of machines of the same or of similar kinds, such as a group of automatics, or gear cutters, or hack saws, being practically uniform, these are often supplied from a common source by one pump, taking lubricant from the same system of piping. But for the big general shops, equipped with a very miscellaneous collection of tools, light and heavy, dealing with all materials of high and low tensile strengths, tough and crystalline, it is better that each individual machine, or each group of similar machines should be provided with its own independent system of supply, and the pump be integral with the machine, or serving the small group. And if any accident should happen to the pump—choking or losing its prime being the most frequent—only the one machine or the small group which it serves is thrown out of action during the period of delay. The size of the pump and its flow can be proportioned to the requirements, as was shown in our previous article of this series.

High pressures, special cases excepted, are not now favoured as much as they have been. Those formerly employed dealt with small volumes of lubricant, and were therefore necessary to convey the heat away. The modern view is that a large volume of liquid, delivered under low pressure is more efficient than one propelled with great force. The latter, too, has the great disadvantage that the fluid splashes off the work, making mess, and causing discomfort to the operator, besides which some portion of its cooling effect is sacrificed.

When dealing with used lubricant, three matters have to be attended to. The collection of the volume discharged, the removal of chips and grit from it (in some cases its sterilization, as when it has been found to produce sores on the hands of attendants), and its storage ready for re-employment. A collecting and filtering system lessens fire risks, because large bodies of oil are not located about the machines. The supply passes through piping and the used oil is drained away through pipes. When a tank is included in the base of a machine, that is usually enclosed. Notwithstanding immensely greater volumes are used now than formerly, there is far less saturation of floors with overflowing and splashed oil than formerly, thanks to improved methods, and in this way fire risks are reduced, as well as cleanliness promoted. A very brief study of these provisions will reveal a wealth of detail which is rather bewildering to old-time hands. Yet the investment involved is justified.

The drawings, Figs. 196 and 197 on the present page show an arrangement of piping which includes a circulating and filtering system, designed by the Richardson-Phenix Company, of Milwaukee, Wis., U.S.A. Here, the machines, which are automatics, are set diagonally in order that the stock fed to each machine shall clear the machine adjacent, and so save floor space. Fig. 196 shows a vertical section through the floor of the shop and basement earth, in which the filter and purifier is located on a concrete base, Fig. 198 is a diagram illustrating the method of supply to a machine, and the drainage of the dirty lubricant. It will be observed that separate drain headers are provided for steel, and for brass to permit of different treatment of the oil from each. The diagram of the piping to the machines is seen in Fig. 196, the pipes supplying clean oil being denoted by full lines and the drainage pipes for dirty oil by dotted lines. Comparing this with Figs. 197, 198, it is seen that the 1¼-inch pipe supplies the lubricant from the pump to the entire system. Thence a ½-inch pipe is taken off to each machine, and a ¾-inch service supply is controlled by gate valves. The waste oil is lifted by a rotary pump from the machine base into a ¾-inch pipe, which delivers to headers 3 inches in diameter, either to the brass, or the steel cuttings drains which go to the filter.

Fig. 196.

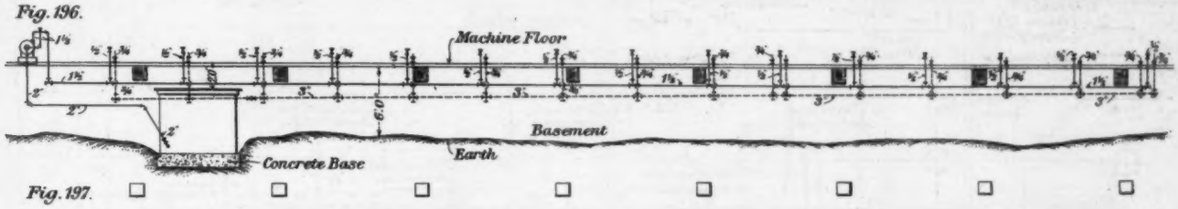


Fig. 197.

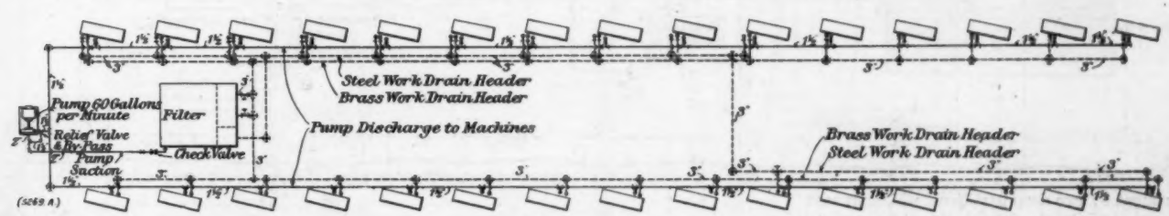
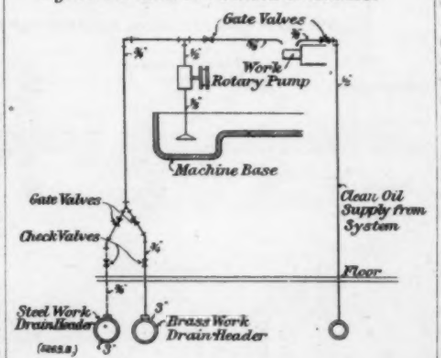


Fig. 198. DIAGRAM OF PIPING AT MACHINES.



Figs. 196 to 198. Pipe Supplies and Filtration Arrangements for Cutting Lubricants. Designed by the Richardson-Phenix Company, Milwaukee, Wis., U.S.A.

These drawings show an arrangement that is somewhat unique. Instead of allowing the dirty oil to run from the base of the machines directly into the drain header, the small rotary pumps on each machine are utilised for pumping the oil from the base of the machines to the drain header. This was done so that in case of any accident to the circulating system, the machines could be switched back on to the old system of circulating the oil from the base through the rotary pump, and on to the work.

Figs. 199 to 203, on page 510, illustrate the system installed in the machine shop of the American Tool Works Company, and laid out by the Richardson-Phenix Company, together with the diagrams of the sterilization and filtration systems. The plan arrangement, Fig. 199, indicates the locations of the machine tools. As in the previous drawing the full lines show the pipes for the supply of clean oil, and the broken lines the drain pipes. By following the course which these take from the horizontal centrifugal pumps at the top left-hand corner of the drawing, it will be seen that the supply pipes diminish from 2½ inch to ¾ inch at the farthest extreme from the pumps, and that the drain pipes increase from 1-inch to 3-inch bore at the filter. Fig. 200 shows the relations of the two sets of pipes, and the flushing arrangement for the drain pipes, to prevent sediment from accumulating, and impeding the free movement of the liquid.

In this plant, the oil is sterilized before it is filtered. The arrangement of the sterilizing, filter, and pipe connections can be seen by comparing the plan view of this section of the plant at the top left-hand corner of Fig. 199, with the similar plan in which the pipes are included Fig. 201, in the end view, Fig. 202, and the side elevation, Fig. 203. The

designations of parts in these drawings will suffice to render the general scheme clear without a description. But some observations on the practice of sterilization, and of filtering seem desirable.

The Richardson-Phenix Company manufacture three types of filters to meet various individual requirements. One design is that of a simple filtering plant, another is a filter equipped with provision for sterilizing, the third is a filter combined with a magnetic separator.

In the simple filter the dirty oil flows into it through three inlet pipes, and down through three deep chip baskets, which are separated from the filtering compartment by two deep partitions, which prevent the oil passing into the filter before it has got to the bottom of the chip baskets. Rising up past the first partition, it flows over the next, and sinks down into the filters, and thence flows through a pipe into the clean oil compartment, from which it is pumped to the overhead reservoir, or into the distributing pipe. In the oil filter which is equipped with a sterilizing tank, the dirty oil enters a compartment in which the bacteria are killed by a steam coil in the bottom of the vessel, or by the introduction of a neutralising agent. The oil flows off into the filter units, passing thence to the clean oil compartment. When a predetermined quantity has accumulated, a steam pump actuated by a float is started, automatically lifting the clean oil to the overhead reservoir.

The third type of oil filter, with which a magnetic separator is combined is useful when steel alone is being operated on, in which case the magnetic separator will remove a large proportion of the chips. But when brass is being tooled, the chips, with which some moulding sand is associated cannot be removed by the separator. In this case a larger amount of filtering surface is provided, The combined filter and magnetic separator include the essential features of the other designs just described. The dirty oil enters the inlets and passes down through deep chip baskets, alongside which is a separating plate or baffle under the lower edge of which the oil passes, then rising and flowing across the magnetic separator which removes the small chips that have passed through the chip baskets. These chips as they accumulate are removed by scrapers which are operated by an endless chain belt that travels across the face of the magnet, scraping the chips off into a retaining vessel at one end. This vessel has holes in the bottom covered with screens through which the oil drains. The chip retainer can be lifted out. The oil that has passed over the magnets falls into the filtering compartment, and thence is collected in a tank ready for use.

The filtering medium used, and its arrangement is a most essential element in the scheme of purification. It is a woven cloth through the meshes of which the oil is forced under a very slight head, leaving the fine particles behind as sediment on the surface, from which the cloth has to be cleaned at intervals. In plants by different firms arrangements vary. In the Richardson-Phenix system the filter-cloth is in the form of a narrow oblong bag, like a U-tube much extended laterally, closed at the bottom and open at the top. This is attached outside a frame with wing nuts. The frame is composed of two sheets of galvanised wire held by surrounding metal and separated by 1 in. The open top is closed with a cover provided with an outlet nozzle. This forms one unit, several of which are enclosed in a compartment. These are disposed vertically, The oil passes from the outside to the inside of the units, and flows off through the outlet nozzles. A head of oil of about 3 in. over the nozzle is necessary for efficient working to afford the necessary difference in pressure between the outer and the inner sides of the cloth. A head very much in excess of this would cause the fine particles of dirt to be forced through the cloth, but it would increase the rate of filtration. Filtration cannot commence until the whole of the cloth is submerged. The vertical disposition of the units is preferred to the horizontal because the sediment in the latter case will collect on the top face of the cloth and form a cake, hindering the work of filtration. In the vertical position the sediment works to the bottom, and drops off, keeping the surface clean and efficient.

A large plant constructed for the Remington Arms and Ammunition Company deals with 24,000 gallons per hour. This was designed by Messrs. S. F. Bowser and Co., of Fort Wayne, Ind., U.S.A. Here the dirty oil is first filtered through chip boxes, each of which is a closed cylinder containing a number of circular iron frames superimposed, with interspaces, and covered with fine mesh wire clamped on a central rod passing down into the chip basket, the whole being enclosed within the cylinder. The oil, filtered through the meshes of the wire, is discharged through a central duct, leaving the chips behind in the basket. The oil, thus freed from the

Fig. 199.

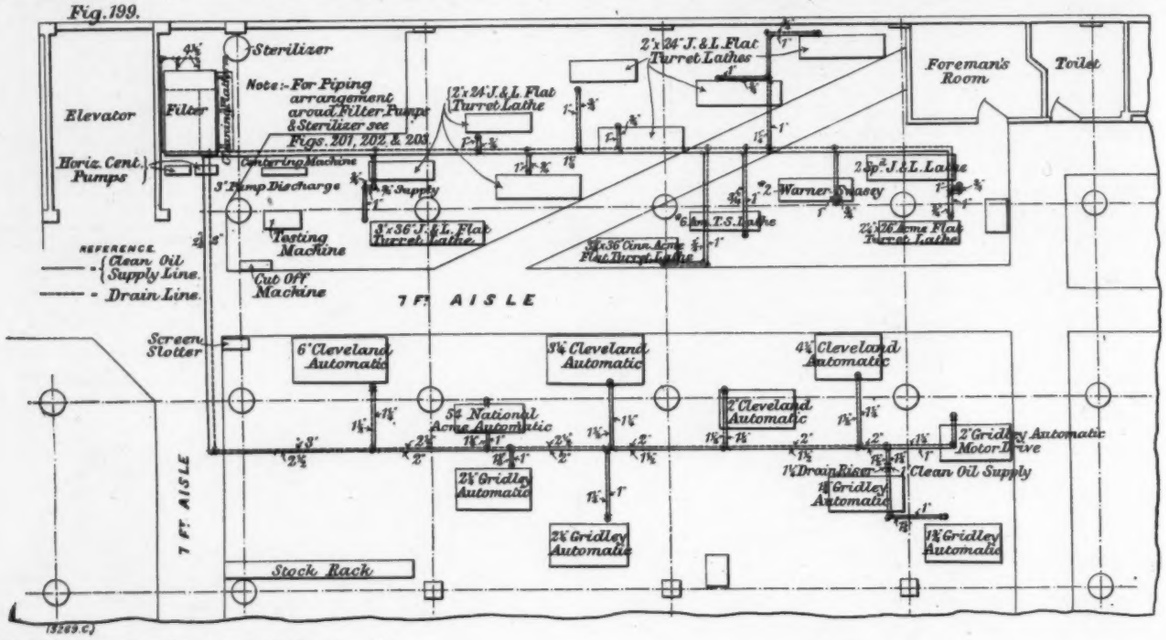


Fig. 200. DRAIN LINE FLUSHING ARRANGEMENT

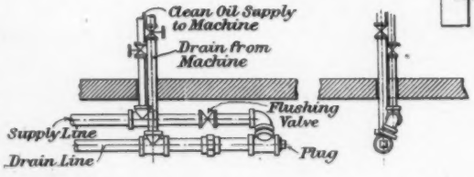


Fig. 201.

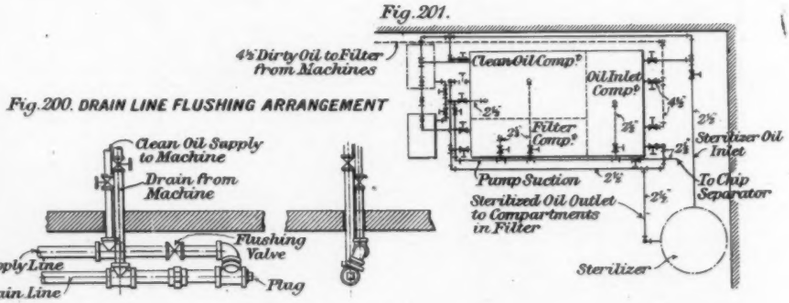


Fig. 202.

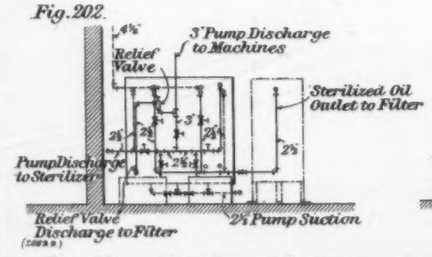
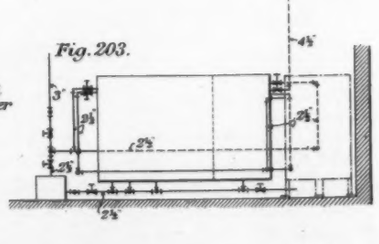

Relief Valve
3" Pump Discharge to Machines
Sterilized Oil Outlet to Filter
Pump Discharge to Sterilizer
Relief Valve Discharge to Filter
2½ Pump Suction

Fig. 203.



FIGS. 199 TO 203. CUTTING LUBRICATION ARRANGEMENTS OF THE MACHINE SHOP OF THE AMERICAN TOOL WORKS COMPANY.

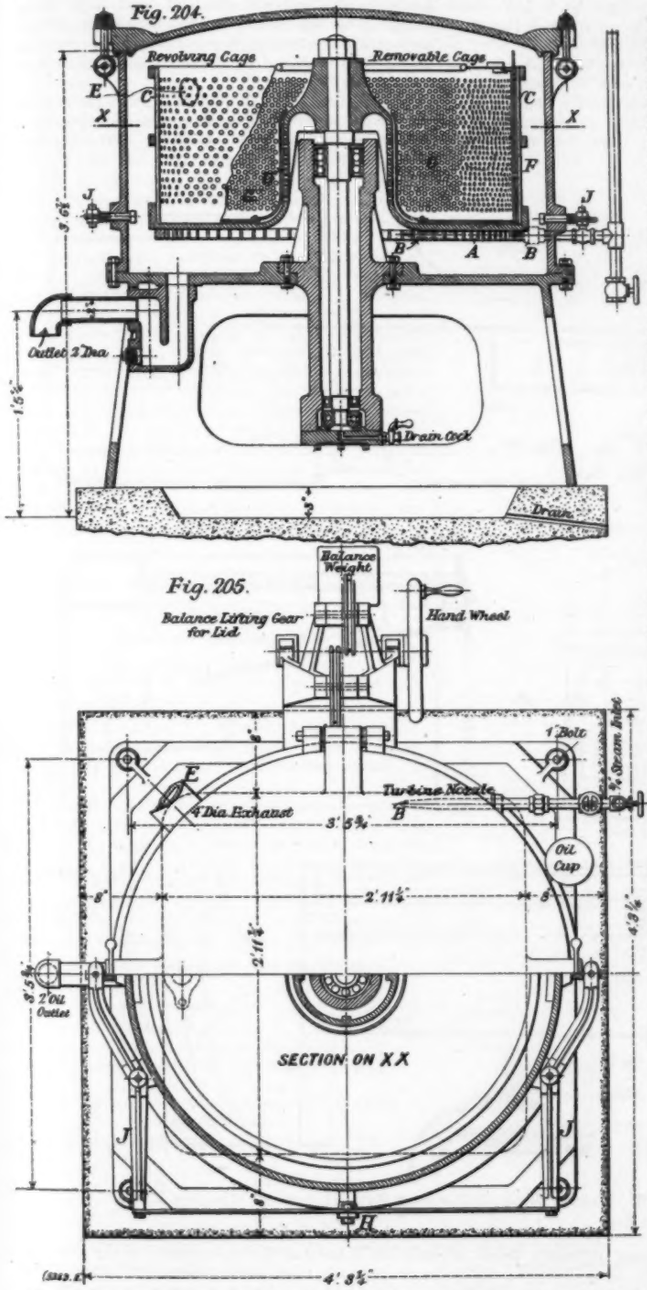
coarser chips and dirt passes into magnetic separating tanks. Electro-magnets disposed in the bottoms of the tanks draw the chips to the bottoms. Time is thus saved by comparison with that occupied in ordinary tanks, in which settlement is due to gravity alone. To prevent the chips from sticking to the bottom when cleaning has to be done, the bottoms are made of brass, so that when current is switched off, the chips can be raked out. Then the oil goes into a battery of filter tanks in which it passes through cloth sleeves, and so to the storage tank ready for use again.

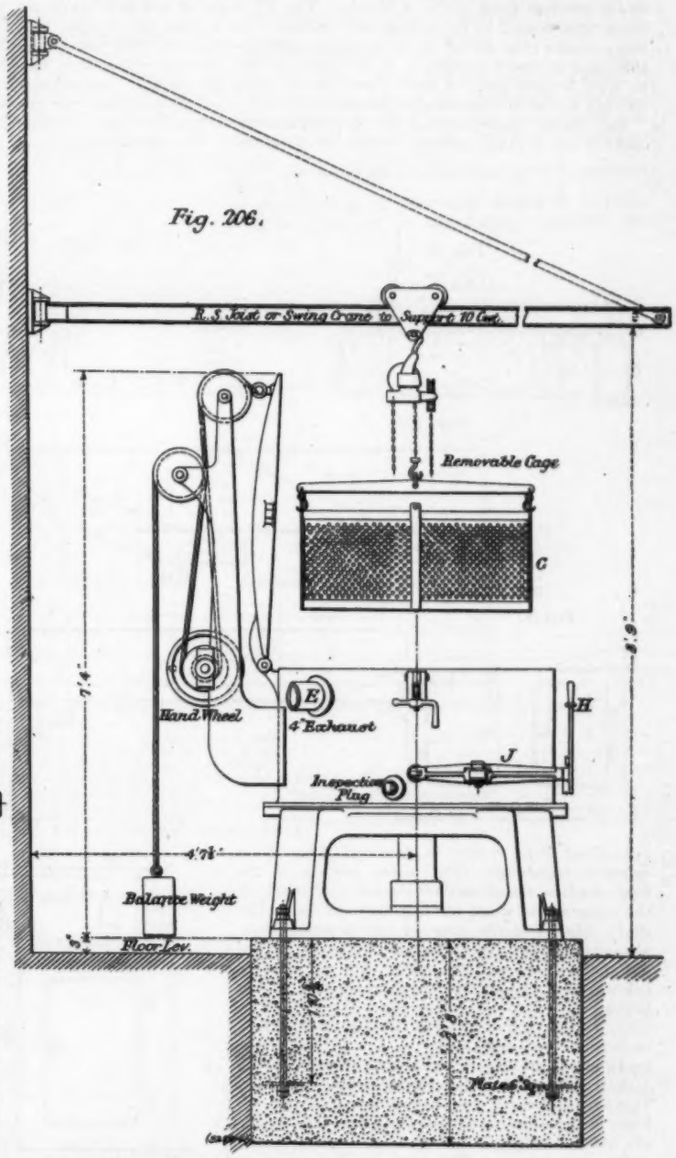
In some of the Bowser plants heat is used to render the oil less viscous and so facilitate the deposition of solids, and also to effect its sterilization. When this scheme is adopted the oil is pumped from the storage tank through heaters provided with steam coils. Thence it passes into two settling tanks in series in which most of the chips fall to the bottom. The oil goes on to the sterilizing tanks where its temperature is raised to about 200 deg. F. On leaving the last of these it is ready to be stored for use. The thick oil which settles and remains in the bottom of the tanks is of too inferior quality to be used for cutting tools, and must be reserved for other purposes.

When machine tools are not connected to a common system of purification, but filtration takes place in the machine a reservoir located below receives the oil supply, and a pump delivers it to the tools. The reservoir should be large enough to expose sufficient surface to ensure the cooling of the oil; baffle plates are frequently fitted in order to prolong the time of settlement of the sediment. But in any case a large volume of oil remains entangled with chips and sediment. It is therefore necessary to employ, in cases where large volumes are used, centrifugal separators to free the chips from the last traces of oil adherent to them. It has been stated that 30 lb. of chips will hold a gallon of lard and mineral oil in contact with them.

A turbine centrifugal extractor and separator is illustrated by Figs. 204 to 206, annexed, as constructed by Messrs. The Industrial Waste Eliminators, Limited, of 20, High Holborn, London, W.C. A steam turbine A, Fig. 204, driven by the jet discharging through the nozzle B, and connected to the perforated cage C, causes the cage to rotate at a high speed. The exhaust from the turbine passes through the dome D, heating the material in the cage, and goes out through the pipe E. (Compare with Figs. 205 and 206,) The oil liquified by the exhaust steam, and separated by the centrifugal action of the cage from the solid residue, is driven out through the perforations in the cage C into the exterior chamber F, and thence through the 2-in. outlet seen at the left hand, where it is collected in a vessel, or in a pipe line for purification in tanks or filters. The removable basket G, with its sediment, is lifted out and taken away for treatment. The basket is seen in its place on the right-hand side of Fig. 204, and the cage C is shown at the left hand, with a portion of the basket broken off. The materials of which the baskets are made are varied to suit requirements. They are of perforated steel, or of galvanised wire. The two are combined when both wiping materials and metal turnings have to be dealt with. It is desirable to have a spare basket to prevent delays in working.

From this general account we may pass to notice some details. A light swinging crane jib, Fig. 206, is pivoted to a wall adjacent, to carry a pulley





FIGS. 204 TO 206. TURBINE CENTRIFUGAL EXTRACTOR AND SEPARATOR, FOR USED OIL; THE INDUSTRIAL WASTE ELIMINATORS, LTD., LONDON.

block, by which the basket G is lifted out of the cage C. The block is hand-operated, with an endless chain and worm gear, and has an automatic friction brake. Three sizes of separators are made having cages respectively of 15 in. in diameter by 8 in. deep, of 20 in. diameter by 12 in. deep, and of 36 in. diameter by 15½ in. deep. The first makes 1,500 r.p.m., the second 1,000 r.p.m., and the third 700 r.p.m. Machines can be arranged for any steam pressure from 20 lb. upwards. The lid is steamtight, hinged to the casing, and secured with two eyebolts (Fig. 204). As its weight is considerable, this is counterbalanced in the manner seen in Figs. 205 and 206. A hand wheel lifts the cover through a rope that passes over pulleys.

The casing which encloses the turbine and the cage is an annular casting bolted to a square open-sided base, which is fastened down to a concrete foundation. The upper portion of the base receives the casing of the vertical shaft, to the upper end of which the cage C is attached. The shaft runs in double rows of ball bearings, both above and below. It is lubricated by the oil thrown out of the drum, and is provided with a drain-cock below. As the speeds of revolution are high, a hand brake is fitted to bring the cage to rest quickly. It is operated by the lever H (Fig. 206), which moves the two side levers J, J, and brings the brake blocks into contact with the periphery of the casting which receives the cage, on its opposite sides. The pins that carry the brake blocks pass through holes in the outer casing (see Fig. 204). The blocks are automatically thrown off from contact by the coiled springs seen. The concrete foundation is shown in these drawings, which illustrate the largest machine made. It is desirable to increase the dimensions given below the floor level when that is practicable, in order to afford the most ample stability to the machine.

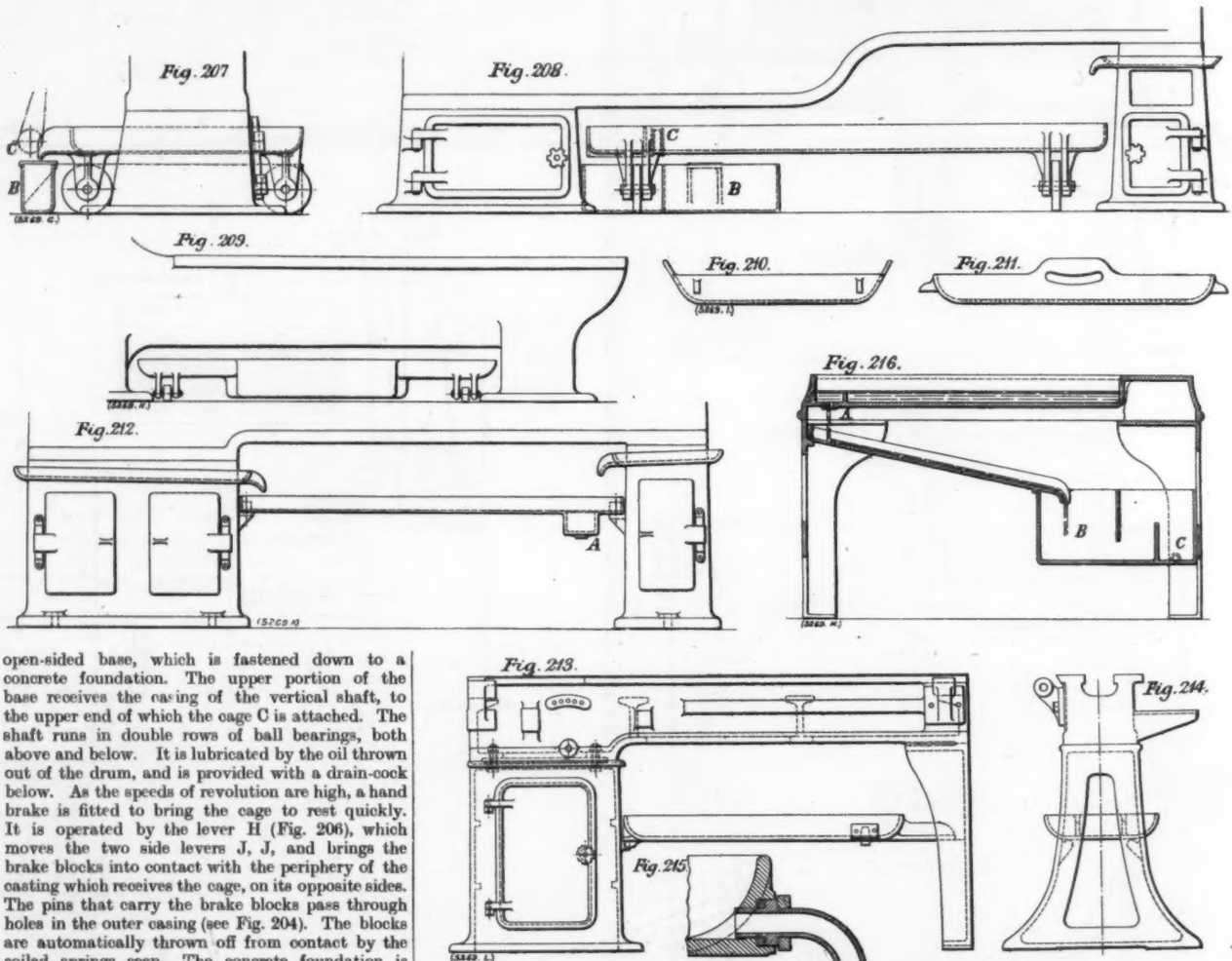
The Wells' filter, made by Messrs. A. G. Wells and Co., London, has the merit of simplicity by comparison with some; comprising a self-contained cylindrical vessel made in sections. It is constructed in four sizes, which cover a range of from 8 gallons to 55 gallons a week, in the following design: Three movable compartments are superimposed. The top chamber receives the dirty oil. Here it remains for about 12 hours while the sediment is settling to the bottom. Then a syphon which is attached to a float is set in action, and the longer arm coming outside the chamber, draws off the clear oil, which falls into the second chamber that is provided with a lip to receive it. Here it passes through a filtering pad, composed of several layers of compressed cotton wool, more highly compressed around the edges than about the centre, to prevent the dirty oil from creeping up the sides of the box. The oil passes down through a tube to a second filtering pad in the lowest chamber. Overflowing, it collects in the bottom of the chamber, to be drawn off for use. Two other filters are made, a very small one, holding 1 gallon of oil, with no syphon, and only one filtering chamber. The other will deal with from 200 gallons to 250 gallons a week, and is fitted with two steam coils and three separate filtering pads. The settling chamber is divided into two compartments, each holding 25 gallons, and arranged with separate floating oil feeds, so that one portion of oil is being filtered while the other is settling.

The provisions that are made for distributing cooling liquids to the many different kinds of machines and tools have now become highly elaborated and perfected in the designs of the manufacturers. They comprise systems of piping, and many forms of nozzles. Complication arises out of the movements of the tools and of the work, and by the locations of the cut or cuts which are being tooled over separate sections at the same or at different times. Flexible hose-jointed pipes, and broad-spreading discharge nozzles are very helpful in such cases. It is better to employ low pressures and large volumes of fluid than to adopt the other expedient. Supply pipes of less than ¾ in. or ½-in. bore are undesirable. Smaller pipes are liable to become choked if grit gets into them or if the lubricant should gum. A large volume of lubricant prevents the work from becoming overheated, from which incorrect dimensions result. Lubricant used in small quantities, getting hot, fails to effectively cool the work.

The collection of the used fluid is effected through some kind of provision that is embodied in the machine, incorporated in its original design. In many of these, notably in the automatics, the machine-bed stands in a chip pan, which entirely surrounds it, and prevents oil and chips from dropping on the floor. In others the chip pan is an extraneous fitting, being portable to be run under the machine, or bolted up to brackets underneath.

Figs. 207 and 208, subjoined, show a pan which is as broad as one of those that is cast integral with a machine, and with the advantage that the running out of the pan for the removal of the chips is an easier task than getting them out of one that is a fixture. As it does not extend to the end of the bed, the right-hand cabinet leg is surrounded by a channel A, the contents of which drain into the pan. The liquid portion of the contents of the pan drains into the tank B, which is a fixture. It contains the pump, driven by the belt pulley C.

Fig. 209 represents a portable pan with the inclusion of a well into which the liquid drips through a strainer. In designs of this class the strainer is a loose fitting from which the chips are removed when they accumulate. Such strainers are fitted in various ways. One is shown in Figs. 210 and 211. It rests on the pan by its lugs, and is provided with handles for lifting it by;



FIGS. 207 TO 216. EXAMPLES OF COLLECTING PANS FITTED TO MACHINE TOOLS.

When accumulations grow rapidly, the strainer is often made as an independent element located above the pan.

A tray which is fitted in the machine is shown in Fig. 212. Channels encircle each cabinet leg to direct the lubricant into the tray. A settling chamber A is provided with a grid, and from this chamber the filtered oil is drawn off. In Figs. 213 and 214 another fixed tray is seen. From this the oil is allowed to drain through a bend pipe, Fig. 215. When the bend is turned downward as shown, the tray is being drained, but when the bend is turned up vertically the lubricant is retained in the pan.

Fig. 216 shows a method of separating chips from soapy water on one of the Wicksteed hack-sawing machines. The lubricant, falling into the bed, drains to the end at A, whence it is directed by the sloping trough to the tank B, provided with two baffle plates, over the second of which the lubricant flows to the pump chamber C.

In some cases, as on some Lincoln millers, tanks are suspended on trunnions so that they can be tilted to discharge their contents. The study of provisions of this character would, if followed prove a very extensive one. It includes details of design embodied in machine framings to facilitate the removal and recovery of used oil, and also many which have for their object the protection of the vital parts of machines—provisions for parts which are fixed and those which are movable. These are too extensive to be embraced here. They are mostly of recent growth. They certainly conduce to the efficiency of the machine tools and to the economy of lubricants, while they also promote the cleanliness of their immediate surroundings, and of the shops generally

THE WHIRLING OF SHAFTS.

By H. A. Webb, M.A.

(*Concluded from page* 485.)

§6. Summary of Results.

The results of these calculations may be summarised as follows:—

For a shaft in which $\sqrt{I\,w}$ is constant, including as a special case the cylindrical shaft, Barling's hypothesis gives the correct whirling speed, the empirical correction being zero.

The other five shafts considered may be regarded as severe tests of the hypothesis; in all of them $\sqrt{I\,w}$ has large fluctuations, in one of them the maximum value of $\sqrt{I\,w}$ being 220 times the minimum value of $\sqrt{I\,w}$. For these five shafts Barling's hypothesis, with the empirical correction, gives the whirling speed correct within 1 per cent.

It seems therefore reasonable to infer that for any practical shaft in which

$$\frac{\text{maximum value of } \sqrt{I\,w}}{\text{minimum value of } \sqrt{I\,w}} < 200 \quad . \quad . \quad (29)$$

Barling's hypothesis, with the empirical correction (3), will give the whirling speed correct within 1 per cent.

§7. Further Applications of Barling's Hypothesis.

(i) *Solid Shaft*, in which

$$\frac{D}{D_0} = \left(1 - \frac{x^2}{a^2}\right)^2 \quad . \quad . \quad . \quad . \quad (30)$$

Let the shaft be of length $AB = (\lambda + \mu)\,a$, as in Fig. 8. The interesting feature of this case is that the maximum section of the shaft may be anywhere between the bearings.

$$\left.\begin{aligned} I &= I_0\left(1 - \frac{x^2}{a^2}\right)^3 \\ w &= w_0\left(1 - \frac{x^2}{a^2}\right)^4 \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (30)$$

On Barling's hypothesis the differential equation of the deflection curve is, from (2),

$$(a^2 - x^2)^2\frac{d^2y}{dx^2} + p\,a^4\,y\sqrt{\frac{w_0}{g\,E\,I_0}} = 0.$$

Let

$$p = \frac{1 + \beta^2}{a^2}\sqrt{\frac{g\,E\,I_0}{w_0}}$$

$$\therefore \quad (a^2 - x^2)^2\frac{d^2y}{dx^2} + a^2\,y\,(1 + \beta^2) = 0,$$

of which the solution is

$$y = \sqrt{a^2 - x^2}\left\{A\cos\left[\tfrac{1}{2}\beta\,.\log_e\frac{a + x}{a - x}\right] + G\sin\left[\tfrac{1}{2}\beta\,.\log_e\frac{a + x}{a - x}\right]\right\},$$

where A and G are constants of integration.

The terminal conditions are that when

$$x = -\lambda\,a,\ y = 0,$$

and when

$$x = \mu\,a,\ y = 0.$$

Substituting, and eliminating A and G, we find that

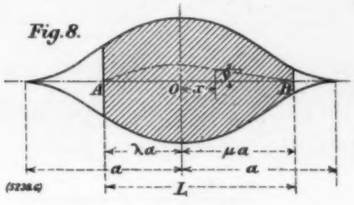
$$\tan\left[\tfrac{1}{2}\beta\,.\log_e\frac{1 - \lambda}{1 + \lambda}\right] = \tan\left[\tfrac{1}{2}\beta\,.\log_e\frac{1 + \mu}{1 - \mu}\right];$$

$\therefore$ for the lowest whirling speed

$$\tfrac{1}{2}\beta\,.\log_e\frac{1 + \mu}{1 - \mu} - \tfrac{1}{2}\beta\,.\log_e\frac{1 - \lambda}{1 + \lambda} = \pi,$$

$$\therefore \tanh\frac{\pi}{\beta} = \frac{\lambda + \mu}{1 + \lambda\mu}.$$

Fig. 8.



(5238.q)

Hence the whirling speed of this shaft is given, subject to the correction by (3), by

$$p = \frac{(\lambda + \mu)^2\,(1 + \beta^2)}{L^2}\sqrt{\frac{g\,E\,I_0}{w_0}},$$

where β is given by

$$\tanh\frac{\pi}{\beta} = \frac{\lambda + \mu}{1 + \lambda\,\mu},$$

L is the length of the shaft,

and $\frac{\lambda}{\mu}$ is the ratio in which the length of the shaft is divided by its stiffest section. (31)

The special cases found from (31) by putting

$$\lambda = \mu = 0.541,$$
$$\lambda = 0,\ \mu = 0.541,$$
$$\lambda = 0.289,\ \mu = 0.577.$$

are shown in Fig. 9.

(ii) Another interesting example is furnished by the shaft for which

$$\sqrt{\frac{I}{w}} = \sqrt{\frac{I_0}{w_0}}\cdot\frac{1 - 4\beta - 16\gamma}{1 - \beta - \gamma}\cdot\frac{1 - (\beta - \gamma)\cos\frac{\pi x}{L} - 2\gamma\cos^3\frac{\pi x}{L}}{1 - 4(\beta - 4\gamma)\cos\frac{\pi x}{L} - 32\gamma\cos^3\frac{\pi x}{L}} \quad (32)$$

where β and γ are any arbitrarily chosen numerical constants.

It is easily verified from (2) that, on Barling's hypothesis, the deflection curve is

$$y = G\left(\sin\frac{\pi x}{L} - \tfrac{1}{3}\beta\sin\frac{3\pi x}{L} - \tfrac{1}{5}\gamma\sin\frac{4\pi x}{L}\right),$$

and the whirling speed is found to be

$$p = \frac{\pi^2}{L^2}\left\{\frac{1 - 4\beta - 16\gamma}{1 - \beta - \gamma}\right\}\sqrt{\frac{g\,E\,I_0}{w_0}}, \quad (33)$$

which must be corrected by (3) in the usual way.

By giving numerical values to β and γ the whirling speeds of any number of shafts can be calculated; the interesting feature is that for most of these shafts the graph of $\sqrt{\frac{I}{w}}$ has undulations.

The special case found by putting

$$\beta = \gamma = 0.02$$

is shown in Fig. 9.

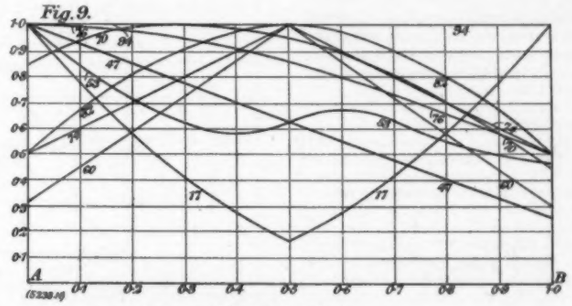
§8. Graphical Summary for Solid Shafts.

The whirling speeds of nine solid shafts of various shapes, found by the preceding calculations, are shown graphically in Fig. 9. The curves represent $\sqrt{\frac{I}{w}}$ for the shafts, which are supposed mounted on free bearings at their ends A and B, and the numbers attached to the curves represent the values of

$$N\,L^2\sqrt{\frac{w_0}{g\,E\,I_0}}$$

for the shafts, where N is the whirling speed in revolutions per minute, and $\sqrt{\frac{I_0}{w_0}}$ is the maximum value of $\sqrt{\frac{I}{w}}$ for the shaft.

Fig. 9.



(5238.q)

N revolutions per minute = whirling speed of shaft.
L inches = length of shaft between bearings A and B.
E lb per sq. in. = Young's modulus of elasticity.
g inches per second per second = acceleration due to gravity.
W_0 lb. = weight of shaft per inch length } at the maximum cross-section.
I_0 inch units = moment of inertia of shaft in bending }
w lb. = weight of shaft per inch length } at any other section.
I inch units = moment of inertia of shaft in bending }

The curves represent $\sqrt{\frac{I}{w}}$,

and the numbers attached to them represent the values of $NL^2\sqrt{\frac{w_0}{g\,E\,I_0}}$ for various solid shafts.

The curves in Fig. 9 are accurate for solid shafts of uniform material, which are long enough for the correction for rotary inertia to be negligible. For other shafts they are not strictly accurate; but they give by interpolation a first approximation to the whirling speed of a large class of practical shafts, mounted on free bearings at their ends.

It is hoped that the curves in Fig. 9 may be of use for design. To find the whirling speed of a practical shaft mounted on free bearings at its ends, draw the curve of $\sqrt{\frac{I}{w}}$, "smooth" the curve out, and estimate the whirling speed by comparison with the curves in Fig. 9. The result is a first approximation and may be checked by the graphical method to be explained later.

§9. Correction for Rotary Inertia of the Shaft.

Suppose the shaft to be performing lateral vibrations, as in Fig. 2.

Let k in. = the dynamical radius of gyration of the section of the shaft through P, about an axis perpendicular to the plane in which the central line of the shaft vibrates.

In the mean position, in which the central line of the shaft is straight, the velocity of P is $p\,y$ in. per second, and the angular velocity of the section through P is $p\frac{dy}{dx}$ radians per second.

Hence in the mean position, the linear kinetic

energy of the shaft is

$$p^2 \cdot \int_0^L \tfrac{1}{2} \cdot \frac{w}{g} \cdot y^2 \cdot dx$$

and the kinetic energy of rotation is

$$p^2 \cdot \int_0^L \tfrac{1}{2} \cdot \frac{w}{g} \cdot k^2 \cdot \left(\frac{dy}{dx}\right)^2 \cdot dx.$$

In the position of maximum deflection, there is no kinetic energy, and the potential energy is

$$\int_0^L \frac{1}{2} \, E\,I \cdot \left(\frac{d^2y}{dx^2}\right)^2 \cdot dx$$

$$\therefore p^2 = \frac{\int_0^L \frac{1}{2} \, E\,I \cdot \left(\frac{d^2y}{dx^2}\right)^2 \cdot dx}{\int_0^L \frac{1}{2} \cdot \frac{w}{g} \cdot y^2 \cdot dx + \frac{1}{2} \int_0^L \frac{w}{g} \cdot k^2 \cdot \left(\frac{dy}{dx}\right)^2 \cdot dx}$$

It appears from this that the value of p found in the previous work, in which the kinetic energy of rotation was neglected, was too high, and ought to be multiplied by

$$\lambda = \frac{1}{\sqrt{1 + \dfrac{\int_0^L w\,k^2 \cdot \left(\frac{dy}{dx}\right)^2 \cdot dx}{\int_0^L w\,y^2 \cdot dx}}}$$

This expression might be troublesome to calculate as the shape of the deflection curve would have to be found first. As, however, we are now dealing with what is, in general, a small correction, it seems reasonable to expect that we shall not introduce an appreciable error by assuming that the deflection curve is a sine curve, as it is for a cylindrical shaft. *i.e.*, write

$$y = a \sin \frac{\pi x}{L},$$

$$\text{and } \therefore \frac{dy}{dx} = \frac{a\pi}{L} \cdot \cos \frac{\pi x}{L},$$

and we find as the approximate correcting factor for rotary inertia

$$\lambda^1 = \frac{1}{\sqrt{1 + \dfrac{\pi^2}{L^2} \cdot \dfrac{\int_0^L w\,k^2 \cos^2 \frac{\pi x}{L} \, dx}{\int_0^L w \sin^2 \frac{\pi x}{L} \cdot dx}}} \quad . \quad (34)$$

λ^1 is easily calculated by graphical integration.

To test the accuracy of this approximation, and also to form an idea of the magnitude of the correction for rotary inertia, λ and λ^1 have been calculated for the shafts that have been considered in this paper, and numerical values found for the cases

$$\frac{L}{k_0} = 10,$$

$$\text{and } \frac{L}{k_0} = 20,$$

where k_0 is the maximum value of k in the shaft.

	Case α. Cylinder.	Case β. Double Solid Truncated Cone.	Case γ. Hollow Truncated Cone.	Case δ. Double Solid Paraboloid.
Maximum k / Minimum k =	1	3	4	6
λ =	$\dfrac{1}{\sqrt{1 + 2\pi^2\left(\frac{k_0^2}{L^2}\right)}}$	—	$\dfrac{1}{\sqrt{1 + (10.2)\frac{k_0^2}{L^2}}}$	$\dfrac{1}{\sqrt{1 + (163)\frac{k_0^2}{L^2}}}$
λ^1 =	$\dfrac{1}{\sqrt{1 + 2\pi^2\left(\frac{k_0^2}{L^2}\right)}}$	$\dfrac{1}{\sqrt{1 + (3.2)\frac{k_0^2}{L^2}}}$	$\dfrac{1}{\sqrt{1 + (8.9)\frac{k_0^2}{L^2}}}$	$\dfrac{1}{\sqrt{1 + (168)\frac{k_0^2}{L^2}}}$
Correction to be subtracted from the calculated whirling speed, if $\frac{L}{k_0} = 10$, = accurately	8.7 per cent.	—	4.8 per cent.	38.4 per cent.
and = approximately	8.7 „	1.5 per cent.	4.2 „	38.9 „
and if $\frac{L}{k_0} = 20$, correction =	2.4 „	0.4 „	1.2 „	15.7 „

We infer from this table that the correction for rotary inertia may be important for short shafts, especially when the sections of greatest inertia are near the bearings; and that the formula (34) for the correcting factor is accurate enough for practical purposes, and may be expected to give results that are correct within 1 per cent.

§10. Graphical Method for Practical Shafts.

We will now investigate a simple graphical method for determining p from the equation

$$\frac{d^2y}{dx^2} + p\,y\sqrt{\frac{w}{g\,E\,I}} = 0 \quad . \quad . \quad (2)$$

with the terminal conditions that

$$y = 0 \text{ when } x = 0, \text{ and when } x = L.$$

In Fig. 10, at A, midway between the bearings O and C, the deflection is a and the slope of the deflection curve is ϕ, *i.e.*,

$$y = a \text{ and } \frac{dy}{dx} = \phi \text{ when } x = \tfrac{1}{2}L.$$

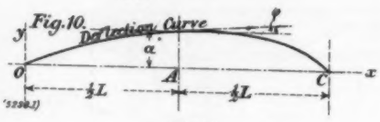
Integrating (2), we find that from O to A,

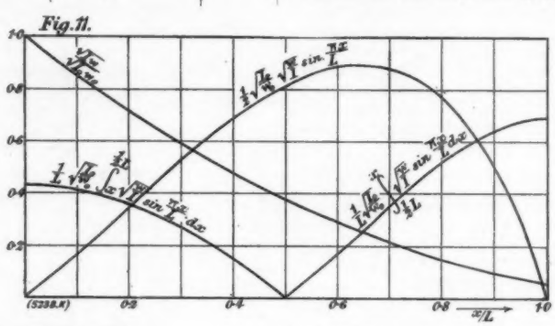
$$\frac{dy}{dx} = p\int_x^{\frac{1}{2}L} y\sqrt{\frac{w}{g\,E\,I}} \cdot dx + \phi$$

and from A to C

$$\frac{dy}{dx} = -p\int_{\frac{1}{2}L}^{x} y\sqrt{\frac{w}{g\,E\,I}} \cdot dx + \phi$$

since $\frac{dy}{dx} = \phi$ when $x = \frac{1}{2}L$.





Integrate again: From O to A

$$y = \phi x + p\int_0^x \int_x^{\frac{1}{2}L} y\sqrt{\frac{w}{g\,E\,I}} \cdot dx \cdot dx,$$

and from A to C,

$$y = -\phi(L - x) + p\int_x^L \int_{\frac{1}{2}L}^{x} y\sqrt{\frac{w}{g\,E\,I}} \cdot dx \cdot dx,$$

since $y = 0$, when $x = 0$, and when $x = L$.

But

$$y = a \text{ when } x = \tfrac{1}{2}L.$$

$$\therefore \quad a = \tfrac{1}{2}\phi L + p\int_0^{\frac{1}{2}L} \int_x^{\frac{1}{2}L} y\sqrt{\frac{w}{g\,E\,I}} \cdot dx \cdot dx$$

$$\text{and} \quad a = -\tfrac{1}{2}\phi L + p\int_{\frac{1}{2}L}^{L} \int_{\frac{1}{2}L}^{x} y\sqrt{\frac{w}{g\,E\,I}} \cdot dx \cdot dx,$$

$\therefore$ by eliminating ϕ,

$$\frac{2a}{p} = \int_0^{\frac{1}{2}L} \int_x^{\frac{1}{2}L} y\sqrt{\frac{w}{g\,E\,I}} \cdot dx \cdot dx + \int_{\frac{1}{2}L}^{L} \int_{\frac{1}{2}L}^{x} y\sqrt{\frac{w}{g\,E\,I}} \cdot dx \cdot dx.$$

It is well known that if, for a given range of values of x, the difference in magnitude of two functions of x is everywhere small, then in general the difference in magnitude of their integrals, and still more of their second integrals, is much smaller.

Now the functions y and $a \sin \frac{\pi x}{L}$ are equal at the three points O, A and C, and both are represented by "smooth" curves; hence it seems reasonable to assume that their difference in magnitude is everywhere small between O and C, and to infer that the error introduced by writing $a \sin \frac{\pi x}{L}$ for y in the double integrals is very small.

Hence we find the equation for p:

$$\left.\begin{aligned} \frac{2}{p} \cdot \sqrt{E\,g} = \int_0^{\frac{1}{2}L} \int_x^{\frac{1}{2}L} \sqrt{\frac{w}{I}} \cdot \sin \frac{\pi x}{L} \, dx \cdot dx + \\ \int_{\frac{1}{2}L}^{L} \int_{\frac{1}{2}L}^{x} \sqrt{\frac{w}{I}} \cdot \sin \frac{\pi x}{L} \cdot dx \cdot dx. \end{aligned}\right\} \quad (35)$$

These integrals are easily calculated graphically, as in §11. In the special case of a shaft symmetrical about the cross-section midway between the bearings the integrals are identical and the labour is halved.

To test its accuracy, this graphical method has been applied to the shafts considered in this paper, with the following results:—

—	Case α. Cylinder	Case β. Solid Double Truncated Cone.	Case γ. Hollow or Solid Truncated Cone.	Case δ. Solid Double Paraboloid.
Maximum $\sqrt{\frac{I}{w}}$ / Minimum $\sqrt{\frac{I}{w}}$	1	3	4	6
Error in value of p when found by graphical method from (35)	Nil	2.8 p.c. too high	2.8 p.c. too high	0.8 p.c. too low

It therefore seems reasonable to expect that the value of p that satisfies equation (2) may be found graphically from (35) with an error of less than 3 per cent.

It may be noticed that the value of p so found tends to be too high when the centre of gravity is eccentric, and also when the maximum value of $\sqrt{\frac{I}{w}}$ occurs near the middle of the shaft.

It should be noticed that the value of p so found from (35) must be corrected by (3), and also, when rotary inertia is not negligible, by (34), to find the true value of the whirling speed.

§11. Example of the Graphical Method.

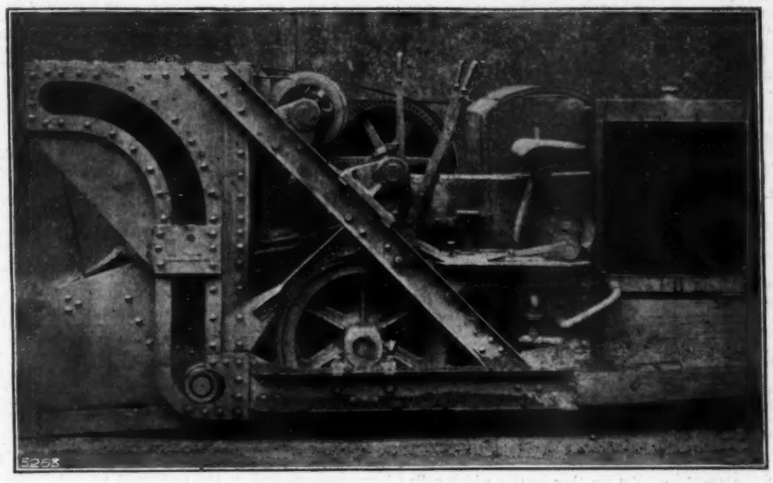
To illustrate the graphical method we will use it to calculate the whirling speed of the hollow truncated conical shaft of Fig. 6, page 484, in which

$$k = 0.234\,l, \text{ and therefore } D_1 = 0.234\,D_0,$$
$$L = 0.766\,l,$$

$$\text{and } \sqrt{\frac{I}{w}} = \sqrt{\frac{I_0}{w_0}} \cdot \left[1 - (0.766)\frac{x}{L}\right].$$

GASOLINE SCRAPER POWER SHOVEL.

CONSTRUCTED BY THE BROWN HOISTING AND CONVEYOR CO., CLEVELAND, OHIO.



x/L =	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
$\sqrt{\frac{I}{w}} \Big/ \sqrt{\frac{I_0}{w_0}} = 1 - \left(0.766\right)\frac{x}{L}$ = ..	1	0.9234	0.8468	0.7702	0.6936	0.6170	0.5404	0.4638	0.3872	0.3106	0.2340
$\sin\frac{\pi x}{L}$ = ...	0	0.3090	0.5878	0.8090	0.9511	1	0.9511	0.8090	0.5878	0.3090	0
$\sqrt{\frac{I_0}{w_0}} \cdot \sqrt{\frac{w}{I}} \cdot \sin\frac{\pi x}{L}$ = ...	0	0.3347	0.6040	1.050	1.371	1.621	1.760	1.745	1.518	0.9950	0
$*\frac{1}{L} \cdot \sqrt{\frac{I_0}{w_0}} \cdot \int_x^{\frac{1}{2}L} \sqrt{\frac{w}{I}} \cdot \sin\frac{\pi x}{L} \cdot dx$ = ..	0.4270	0.4105	0.3592	0.2718	0.1504	0					
$*\frac{1}{L} \cdot \sqrt{\frac{I_0}{w_0}} \cdot \int_{\frac{1}{2}L}^{x} \sqrt{\frac{w}{I}} \cdot \sin\frac{\pi x}{L} \cdot dx$ = ..						0	0.1702	0.3469	0.5121	0.6406	0.6954
$\frac{\sqrt{I\,w}}{\sqrt{I_0\,w_0}} = \left\{1 - \left(0.766\right)\frac{x}{L}\right\}^2$ = ..	1	0.8526	0.7171	0.5932	0.4810	0.3807	0.2920	0.2151	0.1500	0.0965	0.0548

$$\therefore *\frac{1}{L^2} \cdot \sqrt{\frac{I_0}{w_0}} \cdot \int_0^{\frac{1}{2}L} \int_x^{\frac{1}{2}L} \sqrt{\frac{w}{I}} \cdot \sin\frac{\pi x}{L} \cdot dx \cdot dx = 0.1417$$

and

$$*\frac{1}{L^2} \cdot \sqrt{\frac{I_0}{w_0}} \cdot \int_{\frac{1}{2}L}^{L} \int_{\frac{1}{2}L}^{x} \sqrt{\frac{w}{I}} \cdot \sin\frac{\pi x}{L} \cdot dx \cdot dx = 0.2032$$

$\therefore$ from (35),

$$\frac{2}{p} \cdot \sqrt{E\,g} = (0.3449) \cdot L^2 \sqrt{\frac{w_0}{I_0}}$$

$$\therefore p = \frac{5.80}{L^2} \sqrt{\frac{g\,E\,I_0}{w_0}}.$$

To apply the correction (3) we note that the eccentricity of the centre of gravity

$$= e = (0.104)\,L.$$

$$\therefore 3500\left(\frac{e}{L}\right)^3 = 3.94.$$

$$R = \frac{1}{L}\left[\sqrt{I_0\,w_0} - \sqrt{I_1\,w_1}\right] (= 0.9452)\frac{1}{L} \cdot \sqrt{I_0\,w_0}.$$

S^* = average value of $\sqrt{I}$

$$= (0.4296) \cdot \sqrt{I_0\,w_0}.$$

$$\therefore 3500\left(\frac{e}{L}\right)^3 + \frac{5}{9} \cdot \frac{L^2 R^2}{S^2} = 3.94 + 2.69 = 6.63.$$

$\therefore$ by (3) we must subtract 6.63 per cent. from the value of p found above; and the corrected value is

$$p = \frac{5.41}{L^2} \sqrt{\frac{g\,E\,I_0}{w_0}} \text{ radians per second,}$$

which, by (19), is 2½ per cent. too high.

The correction for rotary inertia can easily be found graphically from (34). but it is less than 1 per cent. unless the shaft is very short.

This example was chosen as likely to involve, in its graphical solution, both the greatest amount of labour and the greatest error, because of the eccentricity of the centre of gravity.

* Found by planimeter from the curves in Fig. 11.

§12. Conclusions for Practical Shafts.

The method explained in §10, and illustrated by a numerical example in §11, is applicable to practical shafts of a very wide range. For example, if the shaft consists of a stiff cylindrical core carrying loads, such as electrical winding, &c., which increase the weight without increasing the stiffness, the method is applicable so long as

$$\frac{\text{maximum value of } w}{\text{minimum value of } w} < 40{,}000,$$

where w is the weight per inch length of the shaft. It is hoped accordingly that the method will prove to be of value in design.

The procedure for a practical shaft, freely supported on bearings at its ends, is as follows:—

Draw the graph of $\sqrt{\frac{I}{w}}$ for the shaft. The whirling speed can then be roughly estimated, if desired, from the curves in Fig. 9. The whirling speed is calculated graphically precisely as in the example of §11, by means of the formulæ (35) and (3). In this work the graph of $\sqrt{\frac{w}{I}} \sin\frac{\pi x}{L}$ should not be "smoothed," but drawn accurately. The graph of $\sqrt{I\,w}$ should be "smoothed." Finally, if the shaft is very short, the correction for rotary inertia should be made graphically by formula (34).

The whirling speed so found should be correct within 3 per cent. As has been pointed out in §10, the sign of the error can usually be foreseen, in which case the whirling speed is known within ± 1½ per cent.

A GASOLINE SCRAPER POWER SHOVEL.

We illustrate on the present page an interesting type of shoveller or scraper for coal and ore shovelling, constructed by the Brown Hoisting Machinery Company, of Cleveland, Ohio. This implement, which is driven by a gasoline engine, was designed for use in cleaning up boats of ore and coal, as well as for handling bulk materials of all kinds. The photograph shows the shovel working in iron ore in the hold of a boat. But it will be seen that the shovel can be used for handling various bulk materials.

It may be pointed out that in unloading boats of ore or coal, there is always a certain amount of material that lies between the hatches and cannot be reached by the unloading grabs. The work of the gasoline power scraper shovel is to place this material beneath the hatch openings, thereby doing away with the hand shovellers. The gasoline shovel is able to keep enough material beneath the hatch opening to cause the unloading bucket to get a full load at each grab, and deliver the materials fast enough to keep the unloading machines busy. Therefore it is easily seen that the time of unloading a boat will be materially less than when hand shovellers are employed.

It is of interest to note that the machine was developed by Mr. S. J. Russel, dock superintendent, on the Buffalo, Rochester and Pittsburg Railroad Company's dock at Buffalo. The shoveller consists of a high-powered gasoline engine operating a raisable shovel located at the front end of the machine. When the shovel is raised to its top limit it is in a dumping position, and the load falls out. The entire mechanism is mounted on two rubber-tyred driving wheels, with a third wheel at the rear as a trailer and steering wheel. The two driving wheels are connected to the engine by means of gearing and clutches so as to travel the shovel back and forth. The hoisting drums for raising the shovel and dumping it are also connected to the engine through the gearing and clutches.

It may be stated that all operations are controlled by the operator by means of levers operated and located in front of the seat. Brakes are supplied so as to give the operator better control of the operation. When working in ore and coal in boats, the shovel pushes the material to the desired point, as shown in the view, instead of handling it a shovelful at a time. This makes the operation much faster, as more material is handled at each trip. When working the bow, stern, or against bulkheads, it is necessary for the shovel to handle the material a shovelful at a time, carrying the load to the hatch. This is quickly done, as was proved in unloading the steamer H. J. H. Brown.

It is stated that one of these gasoline shovels took out 100 tons from the bow and delivered it to hatch No. 3 in 45 minutes. This was approximately two hours less time than was required to do the same work with hand shovellers. On a certain class of steamers on which the appliance has been used, some ore is carried beneath the boilers. The shovel reaches this ore and unloads it at the rate of two tons per minute.

It saves time if the shovel delivers the material from two to three hatches to one hatch. It can do this fast enough to keep the unloading bucket busy. By this method, more material is moved in a given time and it provides a larger pile for the unloading bucket to work in. In operation, the gasoline shovel starts into a pile of ore to push the material over to the hatch where the unloading bucket can easily pick it up. The shovel forces its way through the pile, and after it has pushed itself entirely through, and after an opening has thus been made, it proceeds to take its load off the edges.

It is claimed that with this appliance no hand shovellers are required. One sweeper works with the shovel to clean out the same amount of material in the corners. Since the shovel has been used for two seasons, it can be said that it is no experiment. It has been in almost daily service on the docks at Buffalo working in the boats, and its records show it to be a useful machine for two principal reasons. The boat is released anywhere from one hour to five hours sooner than when hand shovellers are used, and it saves the cost of from 12 to 40 shovellers, depending on the type of boat.

Regarding the saving of time by using the gasoline scraper power shovel in boats in which hand shovellers had previously been used, it may be stated that all the boats mentioned below require 12 to 40 men to clean up when the shovel is not used. The steamer W. G. Mather unloaded in two hours less time with two shovels and two labourers, where 49 labourers were employed before. The steamer Ontario unloaded 8,115 tons in 14 hours 10 minutes with hand shovellers, and unloaded 8,316 tons in 12 hours 30 minutes with the mechanical shovel, a saving of 1 hour 40 minutes, even with 201 tons more cargo.

In another instance worthy of mention the steamer Jenkins unloaded 8,951 tons in 13 hours 25 minutes, with one shovel working, and the same boat unloaded with two shovels working 9,121 gross tons in 12 hours 30 minutes. With 170 tons more cargo, the boat was unloaded in 55 minutes less time. The economy of operation has been thoroughly demonstrated, and the cleaning up of the floor is well indicated by the illustration.

THE WORK OF TECHNICAL AND SCIENTIFIC INSTITUTIONS.

Abstract of Inaugural Address by C. H. Wordingham, President of the Institution of Electrical Engineers.

Introductory.—I am deeply sensible of the honour you have done me in electing me your president and am keenly appreciative of the confidence this action implies.

I propose to take for the main subject of my address this evening the Institution itself; to consider how far it meets the needs of the profession and industry and what improvements can be made under its existing constitution; then to inquire whether it may not be possible to raise it to a far higher plane and make it much more potent in the development of electrical engineering. The Institution and the industry should be one, and if they are not it is our business to make them so. There are great problems before us, some present now and some that will confront us in the immediate future, and it will need the fullest co-operation and unanimity on our part as to the action necessary to enable them to be solved satisfactorily.

The Institution as now Constituted.

Its Legitimate Objects.—I will first address myself to a consideration of the Institution as at present constituted. I have been a member since 1884, and of those thirty-three years I have had the honour of serving on the council in one capacity or another for fourteen, so that I have an intimate knowledge of its working. I have seen from time to time, with great regret, indications that many members are not wholly satisfied with the management of the Institution, and have heard that it does not sufficiently represent the industry or look after its interests adequately.

These allegations are, in many instances, based upon ignorance of what the council is doing, but more largely upon a want of appreciation of what it is possible for the council to do. It should never be forgotten that the Institution comprises in its members every electrical interest in the country; those interests are heterogeneous, and in many cases the interests of one section of the members directly conflict with those of another section. How then is it possible for the council in the name of the Institution as a whole to represent adequately the material interests of one particular section without doing an injustice to another section? I have always held the view that the Institution should attend to the promotion of electrical science and its applications to engineering; it should promote research of every kind; it should encourage the spread of scientific knowledge and the improvement of engineering practice; it should set the highest possible standard of conduct and of attainment in knowledge and skill among its members, but it should not attempt to look after the commercial interests of any one section. It is often stated, in a somewhat sneering manner, that the Institution will not demean itself by looking after such sordid considerations as those involved in commercial pursuits, though its members, one and all, have necessarily to pocket their profits if traders, or their fees if consultants, and they have been observed to do so with considerable satisfaction when the receipts have been large.

No greater misrepresentation of the attitude of mind of those who see the limitations I have indicated could be made. The reason that I contend the Institution should not attempt to interfere with commercial matters is that it is impossible for it to do so efficiently. It is of the essence of the successful prosecution of commercial interests that those interests should be common and homogeneous, and I have always held most strongly that each section should organise its own association for the promotion of such interests so as to bring the greatest possible weight to bear by concentrating the whole action in one direction. This course was followed at an early stage by municipal engineers who formed the Incorporated Municipal Electrical Association. Much later there has been formed the British Electrical and Allied Manufacturers' Association to look after the manufacturing interests. Other Associations have been created for other interests which I need not enumerate. There can be no question whatever of the value that these two associations have been to the interests concerned, and this work has been accomplished simply and solely because each has been homogeneous and has only sought to serve the interests of the particular group of individuals affected. If each section is thus benefited it necessarily follows that the industry as a whole is advanced.

Secrecy of Council Proceedings.—I believe also that much apprehension arises from the fact that the proceedings of the council are secret. Representations have been made from time to time to the effect that some account of each council meeting should be communicated to members through the Journal, and an attempt has been made to publish those portions of the council minutes which it has been thought might be communicated without detriment. I am afraid it is impossible effectually to meet this demand. Much of the matter which comes before the Council is of necessity confidential, and negotiations and communications take place which it would be impossible to publish without causing much mischief and defeating the objects in view. Matters apparently of the most harmless possible nature might, if published, give rise to much embarrassment, and in my view the only possible course is for members to trust those of their number whom they have elected to the council and to believe that they are doing their best to ensure the good of the Institution and watch over the interests of its members.

Representation on Council.—This brings me to the very vital question of confidence of the members in the council. It is an unfortunate fact that a very large number of members abstain from voting at the council elections. The normal proportion of votes recorded to voting papers sent out is about 25 per cent. Obviously if members will not take the trouble to secure the return of members in whom they have confidence it does not lie with them to find fault later with the council. Personally I am very fully impressed with the need for a thoroughly representative council, and I should like to see some change made in the mode of its election which would ensure that each section of the members was directly represented thereon in proportion to the numbers in that section. For example, I should like to see the important groups, such as the telegraph and telephone members, the manufacturing members, the municipal members, the company supply members, and so on, each vote for their own representative or representatives, thus ensuring that those representing a specific interest were chosen by the whole body of members devoted to that interest. In addition I would have a certain number elected by the whole body of members independently of any group representation. There would undoubtedly be difficulties in the way of such a modification in existing practice, and the matter cannot be discussed adequately outside the council, but I hope that when the next revision of the articles takes place this matter may be given very full consideration with a view to making the council as representative as possible in every way.

I know that successive councils have tried their utmost to ensure the fair representation of every interest, but the fact remains that in some years one largely preponderates and in other years another, and under the existing system it is almost inevitable that it should be so. Whatever is done, steps must of course be taken to ensure continuity of management of the Institution's affairs, but at the same time there should be combined with this, as now, a constant succession of new blood.

Provincial Members.—Yet another matter which calls for attention is the undoubted feeling that London members have a decided advantage over those living outside London and abroad. Not only are they thought to get more than the other members, but in some quarters there is an idea that there is a tendency for them to run the Institution. Every effort has been made by the council in the past to remove any possible grounds for this feeling. The creation of the Local Sections, their representation on the council, and the weight given to all suggestions received from such sections have gone far to bring members outside London into full touch with the conduct of the Institution. The meetings held locally afford the same opportunities to members of meeting one another and of discussing Institution papers as are enjoyed by the London members; important papers read in London are read also at these meetings in addition to local papers, and there is considerable activity locally, stronger it is true in some districts than in others. The introduction of proxy voting, decided on last session, goes far also to put all members on an equal footing, independently of geographical position.

It is of the utmost importance to the well-being of the Institution that any feeling of the kind I have mentioned should be wiped out; I confess it is difficult to see what more could be done, but I think it would be desirable occasionally to hold a full meeting with president and council in some of the more important centres, such as Manchester, Leeds, Birmingham, Newcastle, and possibly Glasgow. It will be argued by London members that it is making a serious demand on them to ask them to go so far afield as Scotland, but the Scottish members may very well retort that it is just as far from Glasgow to London as from London to Glasgow, and I think the effort ought to be made. Not only would such a course quicken the interest of the members resident in the district, but it would serve the independent purpose of making the Institution better known to those outside the profession.

Work in London.—Turning now to London itself we may well inquire whether the Institution is doing all that it can for the advancement of its legitimate objects. Many members think that it is not, and I am afraid there is some ground for their doubts. This year we are peculiarly handicapped through the commandeering of our building by the Government. I confess it is a very severe disappointment to me personally that it will be impossible to try any of the experiments that I should have liked to see tried during my year of office. I have often felt that the large sums of money invested in the fine building that we possess on the Embankment have not brought in the return in usefulness that they should. The load factor of the building is painfully low, and the stand-by space in the shape of lecture theatre, common room, library, &c., is such as would cause consternation in the mind of a central station engineer. It is true that the lecture theatre is often lent to other societies, but how often is it filled by the members of the Institution? For what proportion of the members is the common room a place of rendezvous? And how many members ever enter the library or avail themselves of the magnificent collection of books therein? When one sees the extraordinary success of such an institution as the Manchester Engineers' Club in bringing together so many different kinds of people interested in engineering and in initiating useful schemes for the good of the industry, one cannot help asking oneself why it is that something of the sort cannot be done and done on a far larger scale by the Institution. It is true that Manchester is an altogether exceptional centre, but there are a great number of electrical engineers within a very moderate radius of Charing Cross, and if only the right scheme could be hit upon I am convinced that the Institution could be made an active centre of everything electrical. Even country members are often in London, and they would soon flock to the Institution if they knew they would meet there the men they want to see.

Informal Discussions.—Without claiming to be able completely to solve this question, I would put forward a few suggestions which I think might be useful. In the first place, there seems to be something about the ordinary formal meetings which is found to be forbidding in some ways to many members, more especially to the younger ones, and there is a want of the sociability and willingness to take part in the discussions which one finds in most of the local centres. Now that meetings have to be held at 6 p.m. I should like to see arrangements made for the meeting to be followed by an inexpensive dinner. This would suit the convenience of many members living out of town, and it would unquestionably promote acquaintanceship between members and greater familiarity among them.

Then, again, I think short informal meetings, at which points of difficulty or special and immediate interest could be discussed in a more or less conversational manner, would be of great utility. Often a burning question arises, frequently at short notice, and it would be of inestimable benefit if the matter could be thrashed out at a meeting at which everybody concerned would be able to put forward his views and hear what his neighbours thought about the matter. Such meetings would encourage the younger members to come forward.

Special Lectures.—Many of the older members of the Institution completed their training more years ago than they care to remember, when electrical science was far behind its present development, and, although each will have kept well up in his particular branch of work, it is impossible for him to follow every development that takes place, and very often an entirely new branch grows up with which he has only a bowing acquaintance. It would be of extreme value if the Institution were to arrange for a series of lectures on special subjects by experts in those subjects setting forth what has been accomplished in the particular branch concerned and giving a general idea of the present position of knowledge. For example, electric furnaces have developed to an extraordinary extent during the last few years; electrical theory has undergone many modifications and much development; a practically new field in electrical cultivation is being opened up, and many other examples will suggest themselves.

Workmen.—Again I should like to see something done with a view to interesting the enormous army of men not qualified to become members in any grade of the Institution, but on whom much of the welfare of the industry depends. I refer to the workmen class.

Permanent Exhibition.—This branch of the work might be supplemented by a carefully organised permanent exhibition of electrical appliances, these being constantly changed, and demonstrations of new apparatus arranged for. It ought to be a well understood thing that if any new useful electrical invention is brought out it can be seen at the Institution as a matter of course, and an explanation of its action be forthcoming.

Research.—So far I have dealt with the more or less public action of the Institution, but much more ought to be done than has hitherto been effected in the direction of research. A useful beginning has been made, but there is a practically limitless field to be covered. Speaking from a very intimate experience of the work, I am of opinion that it cannot be looked after adequately if it be dependent solely upon the efforts of overworked members of council, who can only give portions of their time spasmodically to the work. In my opinion the Institution ought to have one or more well-paid men of the highest scientific attainments to look after technical questions such as research and the organisation of the various fields of activity which I have indicated.

Mandatory Powers.—It is a matter of common knowledge that the electrical industry has suffered severely in the past from ill-advised legislation, but it is not, perhaps, so widely recognised that it has been seriously hampered by the absence of mandatory powers appertaining to any body within the profession. The feeling is widespread that compliance with some standard of education, training and experience should be enforced before a man is allowed to call himself an electrical engineer, and that adherence to certain standards of professional conduct should be a necessary condition of his continuing to practise; at present anyone can call himself an electrical engineer, and no one has the right to object; nay, more, if someone chooses to call himself a member of this Institution there is no legal process by which we can stop him.

The position in regard to the promulgation of rules regulating electrical practice in essential particulars is most unsatisfactory. The Institution has drawn up such rules, but can give them no mandatory force, with the result that those contractors who recognise their necessity and value, and who wish to support the Institution loyally, are placed at a serious and unfair disadvantage in competing with less scrupulous firms who flout the rules, knowing that they can do so with impunity. Bad work is thus put in to the detriment alike of the sound contractor and the public, while the reputation of the industry suffers and its progress is retarded.

The medical and legal professions already have the power to regulate the admission of new members to their ranks and to expel those unworthy to continue in them, and there can be no inherent reason why the engineers on whom depend the lives of countless thousands of the general public should be denied similar powers.

Joint Action of all Kinds of Engineers.—I am aware that there are serious difficulties in giving effect to the views I have enunciated. In the first place, electrical engineers, though they touch at one point or another the work of almost every other class of engineer, are but one of several important groups. Distinct from

them are mechanical engineers and those who practise civil engineering in its more restricted sense of bridge and harbour construction, road-making, railway construction, sewage works, and similar undertakings. It is difficult for one section of engineers to obtain powers not sought by other sections, and unquestionably our efforts ought first to be devoted to carrying with us those other bodies, such as the Institution of Mechanical Engineers, the Institution of Naval Architects, and more especially that mother of Institutions, the Institution of Civil Engineers, to which we, as an institution, owe so much, and members of which were our first founders when we were but a society and were fostered by the Civils. The fact that we have grown so and have become independent should not blind us to its prestige nor make us forgetful of the benefits we have enjoyed; rather should we look forward to greater benefits to be derived from cordial co-operation and an entry as one of several partners junior to the Civils into a solid combination of engineering interests. If our efforts to promote this joint action fail, then we must still try what we can do on our own account, but concerted action must unquestionably give the best results. Engineering in the widest sense would then be placed on the same footing as other professions, and be similarly recognised by Government. The powers and privileges granted would be delegated to, and exercised by, the several institutions for the branches which they respectively represent.

In seeking for powers such as I have indicated I do not wish it to be understood that I think they should all necessarily be vested entirely in the Institution. The powers relating to the entry and continuance in the profession should certainly be granted to the Institution and to no one else, just as the Medical Council controls doctors, and the Law Society solicitors, but the rules for regulating engineering practice and standards may well require some collateral Government action to give them force after the Institution has formulated them.

All Interests Federated under the Institution.—Owing to the importance of certain sections, influential bodies outside the Institution have grown up. I have already stated my conviction that it is eminently right and proper that they should be formed to look after those members who have common material interests. It is, however, equally important that there should be no overlapping, and that they should confine themselves to those branches of work which the Institution cannot do so efficiently as they. I deprecate most strongly anything in the nature of rivalry. The ideal that I look forward to is a strong Institution, endowed with a Royal Charter, recognised as the embodiment of the whole industry as far as those outside it are concerned, invested with full powers as to the educational qualifications to be possessed by all grades of workers in the profession and industry from the highest to the lowest, and effecting under its ægis the federation of all other associations connected with the multifarious branches of electrical work.

Broad Lines of Constitution.—It would be futile to attempt to enter into any detail here. Broadly, my view is that each section should have its own association to look after its commercial interests, such associations being formed if not already existent for a particular branch, and that each should be represented directly in appropriate proportions on the Institution's governing body. The Institution to be given a definite status by the Government and recognised as the only body representing electrical engineering; the Institution to control entry into the profession, and all regulations on electrical matters to be issued at its instigation or in accordance with its advice. Grants in aid of research or other national purposes to be entrusted to the Institution for administration.

It may be argued that the Institution, even though modified in its constitution in the manner suggested, would still have the difficulties I emphasized earlier in my address in regard to the discordant commercial interests of different sections of its members. To some extent this is probably true, but its authoritative position would enable it to compose many differences which it is now powerless to influence, and in very few cases would it be found necessary for any special Association to take independent action, but in the last resort this could be allowed without detriment to the scheme.

Research.

Scientific Research.—With a strong institution such as I have depicted, the field of usefulness would be enormous and the potentialities almost beyond calculation. One of the most important matters demanding attention is research. Scientific research on purely academic lines should be closely pursued, for, after all, in the past it is from such work, having apparently no commercial application, that the industry itself and many of its most lucrative developments have sprung. In the men who devote themselves to pure science, in the professors, in the students just out of their college courses, we have within our membership a magnificent personnel for such work, and if they were organised, the results of their discoveries being brought directly before manufacturers and the needs of manufacturers brought before them, there can be no doubt that we should progress by leaps and bounds. Investigations of this kind need laboratories, and by utilising those that already exist the facilities at our disposal would be immense.

Industrial Research.—Equally important is industrial research, by which I understand the development of scientific discoveries in such a way as to found on them industrial processes, and the experimental development of new methods of manufacture to attain definite desired results. Here the work must fall on manufacturers who alone have the facilities and the experience required for the prosecution of the work.

Scientific and Industrial Co-operation.—The point I wish to make is that the workers at both kinds of research should be welded together so as mutually to assist one another, and so that the manufacturers may have a call on the highest talent in the country, while the scientific seeker after discoveries may avail himself of the resources of the manufacturers to test any promising inventions he may make. Such co-operation must tend to give far better results than any independent efforts of one class of worker without the other.

Scientific Laboratories.—While advocating the utilization and co-ordination of those facilities which exist, I do not, of course, overlook the need for supplementing them where incomplete by other laboratories. In the National Physical Laboratory we have magnificent facilities for scientific investigation of the highest class, and now that it has been taken over by the Advisory Council for Scientific and Industrial Research it may be hoped that it will in future be supplied with adequate funds by the Government. In such event it would probably be unnecessary to establish any additional laboratory for scientific research, since in conjunction with the facilities at the University and Technical colleges of the country ample provision would be made for this class of research.

Objects of Research.—Industrial research stands on a very different footing in every way. To begin with, the objects in view of the worker differ fundamentally; apart from his desire to advance the world's knowledge, the experimenter in pure science is usually chiefly concerned with his reputation, and is eager to publish his results to the world so as to get the credit of his discoveries. The industrial experimenter, on the other hand, has for his main purpose the improvement of his manufacturing methods and the securing, if possible, of profitable monopolies. The last thing he desires, as a rule, is to publish his hardly won knowledge for the benefit of his trade rivals, British and foreign.

This fundamental difference in the objects of the workers involves important considerations in the promotion of research out of national funds. If industrial research is to be of real value to the nation it is essential that much of the work done shall be kept secret and only imparted to those who will directly utilise the information obtained for the benefit of British trade. Obviously it would be folly to spend public money and employ the abilities of some of the ablest men in the country in the development of new or improved processes of manufacture and then to publish the results for gratuitous use by the enemies of British trade. Fortunately, this has been recognised from the first by the Advisory Council of Research, to whom the administration of the funds voted by Parliament has been entrusted and much valuable work has been, and is being, done to enable British manufacturers to produce articles formerly obtained from abroad, such articles in many cases being of superior quality to the foreign ones.

Electrical Engineers.

Consultants.—There is a tendency at the present time to regard manufacturing as synonymous with electrical engineering and to disregard the other branches of the latter, more especially to belittle the consulting engineer, many going so far as to say that he will shortly disappear. While recognising to the full the importance of the position of manufacturers and the shortcomings of many of those calling themselves consultant, I think it would be a distinct loss to the profession were the consulting engineer to be eliminated and his work taken over by the manufacturer. The lopping off of a branch corresponding to the highest positions in civil engineering and in other professions, such as the medical, would be greatly to be deplored, as it would mean the narrowing down of a profession which now embraces every branch of an engineer's work. Apart from this, there would be a distinct loss to the industry. From the manufacturer's point of view, it is clearly advantageous to have someone who can state the purchaser's requirements in a definite manner in terms that can be understood without ambiguity, so that all tenders are on an equal footing, and who is able to appreciate the relative values of the offers firms make irrespective of the persuasive powers of their representatives. From the purchaser's standpoint, the consultant necessarily takes a broader view, and his advice is likely to be more reliable, than that of any individual firm of manufacturers who, however honest in intention, must necessarily be biased in favour of their own methods of attacking a problem and who will be tied largely to their own designs which may not be uniformly the best. In my experience, also, the consultant is often able materially to assist manufacturers by putting before them the needs of users that they would never have thought of, and by defining precisely the conditions to be fulfilled in a manner that the user never could, on account of his not possessing the necessary technical knowledge to enable him to do so.

Engineers and the Public.—It is a matter for surprise that engineers should count for so little in the public eye. The man in the street knows little, usually not even the names of our most famous engineers, while singers of senseless songs, vulgar buffoons, food faddists, cranks-authors of nasty or silly novels, and the propounders of grotesque views on religious matters, are with him household words. Politicians also of every kind occupy a prominent place in his admiration. Why is this? Largely, no doubt, because the average intellectual level in any country is low and any individual whose mind is above it can make no appeal to the average man, while the popular heroes more often appeal to the passions common to all mankind rather than to the mind the quality of which varies so much. Partly, however, engineers themselves are to blame. They have, as I have said, let others occupy the prominent positions that are theirs by right, those positions which bring them most into contact with their non-engineering fellow-men, and have perhaps been apt to look with contempt on popular appreciation and on the shifts of notoriety seekers. We are often told that this is an engineer's war—a doubtful compliment—but unquestionably the public has had brought home to it the resourcefulness and widespread power of the engineer, and a large number of people have acquired a smattering of engineering which however small, must tend to increase respect for our profession. The time, therefore, seems ripe for a change.

Engineering as a Profession.—A word as to engineering as a profession: it surely, rightly apprehended, is one of the most ennobling. It requires an active brain, making, as it does, a direct appeal to the intellect, and it brings a man into intimate contact with the laws and processes of Nature and their everlasting truths, while constructive work is the nearest approach to creation possible to a created being. Contact with Nature at first hand and the consequent realisation of the puniness of man, as well as of his infinite possibilities, must surely engender a spirit of reverence and broaden the mind in a manner few vocations can. It is a boon of priceless value for a man to find himself in daily contact with men of sense and knowledge, and as he progresses in his profession to have for his companions and intimate friends those who are in the forefront of thought and discovery and also are among the brightest intellects of his day; it may tend to humility, but it will certainly sharpen his wits and make life better worth living.

I would particularly impress on the young engineer the need for thoroughness in all he does—"Whatsoever thy hand findeth to do, do it with thy might" is a maxim applying with peculiar force to engineering. Every piece of work carries with it three potentialities or values. The first is its money-getting capacity; at this many stop; they may become the richest in their profession but they will not be its leaders. The second is the possibility of an enduring monument of the engineer; this is far greater than the first and of vastly more value to him as a man, and it will help forward him in his profession. Lastly there is the training in experience and in character, and this is the most valuable of all.

Strive after perfection and do not regard the smallest job as unworthy of your best efforts. Always say to yourself: "This work that I am doing will remain perhaps long after I have disappeared—let there be nothing in it of which I need be ashamed hereafter"; let it be impossible to find in it in later years any sign of scamping or subterfuge. Let love of your work for the work's sake be your dominant motive and do not aim lower than perfection even though absolute perfection may be unobtainable; believe me the more material benefits will be added to you.

Reduction of Rolled Sections in the German Iron Industry.—A number of unions in the German iron industry recently decided upon reducing the number of kinds of manufacture, and a simplification of the normal profiles of rolled steel for building purposes is now to be brought about. Even before the war such simplification was considered advantageous and had been discussed, but now it has become a necessity. A simplification of what is called the rolling programme will, it is expected, to some extent serve to do away with the difficulties now existing as regards the delivery of steel of all kinds. A selection of the existing sections has therefore been made in conjunction with representatives of users, and for the future the consumers in their own interest, will have to confine themselves to this reduced number. The sections selected will in the first instance answer the requirements of the constructing firms, but also the manufacturers of wagons and machinery have been duly considered. The manufacture of special sections for special purposes will not be discontinued, only the buyers of such sections must make their own arrangements about delivery.

Joint Committee on Gas Traction.—A Joint Committee of the Commercial Motor Users' Association, the British Commercial Gas Association, and the National Gas Council is being appointed to encourage the use of gas as a fuel for motor-traction purposes. Mr. E. S. Shrapnell-Smith (chairman of the Joint Committee of Mechanical Road Transport Associations) will be the chairman of the committee, and Mr. Frederick G. Bristow, F.C.I.S., secretary of the Commercial Motor Users' Association, 83, Pall Mall, S.W., will act as hon. secretary. Active steps have already been taken in various directions, including the following: (*a*) Arrangements are well in hand for the publication of a list of stations throughout the country where flexible gas containers can be filled. (*b*) Representations have been made to the Local Government Board urging the expediency of allowing the legal speed of a vehicle when drawing a trailer used only to carry a gas container to be such as if no trailer were so drawn. (*Note.*—The legal speed of any vehicle drawing a trailer exceeding 2 cwt. in weight unladen is 5 miles per hour.) (*c*) Steps are being taken to secure increased supplies of meters and fittings, uniformity in the size of connections, and the adoption of the same rate per 1,000 cub. ft. of gas as is charged for gas used for power purposes. (*d*) An enamelled sign of distinctive design is being prepared for exhibition outside the premises where facilities are available for the filling of containers. (*e*) The Inland Revenue authorities have been approached suggesting that the Weights and Measures Department should add to its existing organisation the question of officially registering the capacity of each gas container.

THE LIFTING MAGNET AS AN ADJUNCT TO THE ELECTRIC STEEL FURNACE.

One of the most striking features in connection with steel manufacture all over the world has been the rapid advance made in the art of making and refining steel in the electric furnace. Large numbers of these furnaces have been put down in this country and already the results obtained, both technically and in increased tonnage, have been remarkable. In many cases steel of the highest grade is being made from such material as turnings, and when the unsuitability of such scrap is considered from the point of view of the open hearth furnace it will be seen that the electric furnace fills a strong position in these days of shell manufacture, by absorbing what in earlier days proved almost a drug in the market, namely, small turnings and borings.

It was for dealing with this small scrap that the lifting magnet first proved its utility to the steel manufacturer. To load the charging trays and boxes by manual labour is quite a problem. In the first instance it is a slow business to pick up the turnings by the shovelful or by the forkful and entails the employment of quite a lot of labour. The nature of the work is also against manual handling, as it is not only troublesome but it is also the source of many minor accidents, as steel splinters frequently penetrate the hands of the labourer.

Other uses for a lifting magnet when handling scrap were found after a time, and it is no exaggeration to say that to-day the lifting magnet and magnet crane are probably the most valuable adjuncts the manufacturer of electric steel possesses.

The accompanying photographs were taken at the works of the Stobie Steel Company, Limited, Dunston-on-Tyne, and illustrate very effectively the valuable nature of the services rendered by the Allen West Lifting Magnet installed there. Incidentally, the photograph showing the magnet used as a stripper (Fig. 2) illustrates the remarkable pouring qualities of the steel and smooth ingots produced by the Stobie electric furnace.

Fig. 1 shows the magnet which is 36 in. in diameter unloading scrap from the railway trucks on to the dump. This work can only be done efficiently with a magnet, since with manual labour trucks are held too long, and a grab bucket limits the general use of the crane and requires excessive head room. With a magnet the dump may be taken up to within 1 foot or two of the crane level and valuable floor space is saved. It should be remarked that it is advisable to store turnings under cover as far as possible to prevent excessive rusting, and high dumps are obviously an advantage.

For charging purposes the magnet loads the charging trays in a few minutes, the average lift being 7 cwt. to 8 cwt. of turnings per trip. Owing to the quick energisation of the magnet and its instantaneous release of the load, Messrs. Stobie have developed an exceedingly fast method of using it.

It should be remarked that the magnet is fitted with rigid link suspension and has a long "eye." By this means the crane driver, after getting one of the men about the steel works to disconnect the watertight plug connection used for the electric cable, is able to take his magnet to any convenient place, say at the top of the dump, and disconnect his hook himself, leaving the magnet there while he connects his hook to the charging tray, which is fitted with a similar eye, and proceed to the furnace, where he discharges his load.

On returning for the magnet he is able to re-arrange the hook without any assistance and gets his plug reconnected at any convenient points in the works. This feature, although only a detail, will no doubt appeal to steel works managers.

After the steel has been melted, it is teemed into the ladle and then into ingot moulds (Fig. 2). While the ingot is still red hot the crane driver proceeds to use his magnet as a stripper, and the fact that he is able to do so is a tribute to the attractive force of the magnet and to the quality of the ingot. The magnet is called on to break the mould out of the dried ganister at the bottom and to strip it from the ingot. The weight of the mould is about 14 cwt. Although very occasionally "stickers" are met with, we are informed that the bulk of the ingots cast are dealt with by this method.

As soon as the mould is clear of the ingot it is taken to another part of the works and may be placed in any position by the crane driver without assistance. When sufficiently cool the ingots themselves are picked up by the magnet and conveyed about the works as desired. Our illustration, Fig. 3, shows the magnet lifting four ingots each approximately 15 cwt., or a total of 3 tons of ingots.

The magnet illustrated was designed and built by Messrs. Allen West and Co., Limited, at their works at Brighton, and its performance, as outlined above, we think, speaks for itself. The makers inform us that in addition to being able to work hot metals without injury all their magnets may also be worked submerged, being impregnated and absolutely watertight.

THE LIFTING MAGNET IN THE STEEL FOUNDRY.

CONSTRUCTED BY MESSRS. ALLEN WEST AND CO., LIMITED, ENGINEERS, BRIGHTON.

Fig. 1.

Fig. 3.

Fig. 2.

THE PAUL GIROD ELECTRIC STEEL FURNACE.

CONSTRUCTED BY THE COMPAGNIE DES FORGES ET ACIÉRIES ÉLECTRIQUES PAUL GIROD, UGINE, SAVOIE, FRANCE.

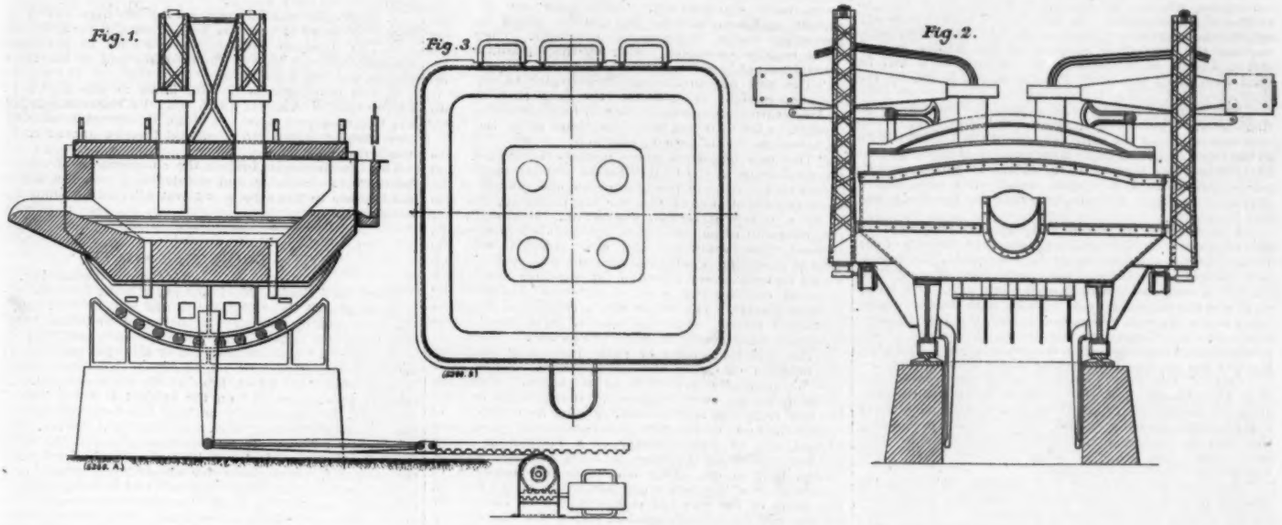


FIG. 4.

THE Paul Girod electric steel furnace is an arc furnace having a conducting hearth. The current, which is supplied through the carbon electrodes suspended over the furnace body, forms an arc over the surface of the metallic bath, goes through this latter, and leaves by the hearth. The furnace is built by the Compagnie des Forges et Aciéries Electriques Paul Girod, Ugine, Savoie, France, whose works are illustrated in the view Fig. 4, Figs. 1 to 3 above, and Fig. 5 on page 522, showing the furnace.

Conductivity in the hearth is obtained by embedding bottom electrodes in the refractory lining, made of dolomite or magnesite; the bottom electrodes are of mild steel, they run through the furnace bottom plate and slightly project inside the furnace above the refractory lining. The bottom electrodes, which are six in number for a 2-ton furnace and sixteen for a 20-ton furnace, are placed at an equal distance apart, round the periphery of the hearth. The upper part of the bottom electrodes in contact with the bath melt over a height of from 5 cm. to 6 cm. (1.9 in. to 2.3 in.); the lower part, outside the furnace plating, has a cavity in which there is provided water circulation, the effect of which is to decrease the length subject to melting and to tend to increase the life of the refractory hearth. The connection for the outgoing current is made below the bottom electrodes.

The furnace is covered by a silica brick arch in which are cut the openings for the carbon electrodes, a small clearance being provided between these and the sides of the openings. The charging door is at the back of the arch. The metal bath is 20 cm. to 30 cm. (7.8 in. to 11.8 in.) in thickness. The dimensions and number of the upper electrodes vary with the size of the furnace. The furnaces of from 2 to 3 tons have one electrode; those of larger size have a suitable number, divided over the surface of the bath and forming as many sources of heat, with the object of equalising the temperature throughout the whole of the furnace. The 20-ton furnaces at the Ugine steel works have four carbon electrodes. Whatever be the number of carbon electrodes, they are connected in multiple, and the furnace is supplied with direct or single-phase current. It is possible, and also advantageous in certain circumstances, to make three-phase connections in furnaces having three, or also an even number of electrodes, in which case the conducting hearth is also resorted to, the furnace working equally well as with the other arrangement. The principle of having a conducting hearth, which compels the current to flow through the whole of the charge, is particularly advantageous from several points of view. When starting with a cold charge the furnace works almost entirely by resistance, and heating is carried out regularly over the whole depth of the charge. This working by Joule effect is, of course, only of small importance after melting has taken place; it is not negligible, nevertheless, and no doubt it is one of the causes by which the method comprising a conducting hearth also secures the equalising of the temperature in the bath. The current circuit from the carbon electrodes to the hearth, through the bath, forms one arc and makes it easy to control the working of the furnace. Each electrode has its own regulating device, which operates independently of the working of the other electrodes.

From the metallurgical point of view the operation for the manufacture of steel is always carried out in one and the same way. A charge of scrap and steel turnings is introduced, with material for a preliminary slag, consisting of lime and iron ore; the mixture of this oxidising slag is such that when melting is complete the metal bath must be completely refined—the composition being: carbon, 0.1 per cent.; silicon, 0.05 per cent.; manganese, 0.1 per cent., as shown by test specimens. If necessary, the action of this oxidising slag is extended, or it is strengthened by the addition of iron ore until the required degree of refining is attained.

The preliminary slag is then poured out and is replaced by an extra-basic slag obtained by the addition of pure lime; this calcareous slag, in the presence of the refined and oxidised bath, ensures active dephosphorising. When the calcareous slag has been very carefully removed the bath is ready for deoxidising and recarbonising, and the giving of the required character to the metal; these latter operations are carried out in the presence of a neutral slag composed of lime and silica. Recarbonising is effected with charcoal, or with powdered or agglomerated graphite; deoxidising is carried out by the addition of energetic reducing agents such as silicon, manganese, aluminium, in the shape of ferro-alloys, and carbon. These reducing agents act either in the bath itself or in the slag, where they reduce the oxide of iron which this latter tends to absorb. Towards the end of the deoxidising period, thanks to the sufficiently high temperature, to the basicity of the slag and its low content in iron oxide, an intensive desulphurising action takes place. The percentage of carbon is made up by the addition of coal or pig-iron, and the operation is completed by the addition of silicon, manganese, nickel, chromium, tungsten, &c., varying with the grade of steel required.

According to the purpose to which the steel is destined, the operation is carried out so as to arrive at a greater or lesser degree of refining; thus the percentages of sulphur and phosphorus, which may be 0.020 per cent. in ordinary steels, are lowered to 0.005 per cent. in special and tool steels.

THE EVOLUTION OF THE UNITED STATES STANDARD AVIATION ENGINE.

The United States Secretary of War has recently issued a statement describing the steps taken to obtain a standard design of engine for use in the vast fleet of aeroplanes which our American friends have now in course of construction. In view of the urgent necessity which exists for reducing the number of types of aeroplane engines the procedure adopted in the States is well worth serious attention and the account of it will be read with great interest. The statement issued by the Secretary of War is as follows :—

"The 'United States aviation engine' has passed its final tests. They were successful and gratifying. The new engine is now the main reliance of the United States in the rapid construction in large number of high-powered battleplanes for service in the war. In power, speed, serviceability, and minimum weight the new engine invites comparison with the best that the European war has produced.

"I regard the invention and rapid development of this engine as one of the really big accomplishments of the United States since its entry in the war. The engine was brought about through the co-operation of more than a score of engineers, who pooled their skill and trade secrets in the war emergency, working with the encouragement of the Aircraft Production Board, the War Department, and the Bureau of Standards. The story of the production of this engine is a remarkable one. Probably the war has produced no greater single achievement.

"One of the first problems which confronted the War Department and the Aircraft Production Board after the declaration of hostilities was to produce quickly a dependable aviation engine. Two courses were open. One was to encourage manufacturers to develop their own types; the other to bring the best of all types together and develop a standard.

"The necessity for speed and quantity of production resulted in a choice of the latter course, and a standard engine became our engineering objective.

"Two of the best engineers in the country, who had never before seen each other, were brought together at Washington, and the problem of producing an all-American engine at the earliest possible moment was presented to them. Their first conference, on June 3, lasted from afternoon until 2.30 o'clock in the morning.

"These two engineers were figuratively locked in a room in a Washington hotel and charged with the development of an airplane engine for use by American aviators over the battlefields of Europe. For five days neither man left the suite of rooms engaged for them. Consulting engineers and draughtsmen from various sections of the country were brought to Washington to assist them. The work in the draughting room proceeded continuously, day and night. Each of the two engineers in immediate charge of engine development alternately worked a 24 hour shift.

"An inspiring feature of this work was the aid rendered by consulting engineers and engine manufacturers, who gave up their trade secrets under the emergency of war needs. Realising that the new design would be a Government design and no firm or individual would reap selfish benefit because of its making, the engine manufacturers, nevertheless, patriotically revealed their trade secrets and made available trade processes of great commercial value. These industries have also contributed the services of about 200 of their best draughtsmen.

"The two engineers locked together in a hotel room in this city promised the Government, if given an opportunity, they would design a satisfactory engine before a working model could be brought from Europe. A remarkable American engine was actually produced before any model could have been brought from Europe. It was promised that this engine could be developed before the Fourth of July. Twenty-eight days after the drawings were stated the new engine was set up. This was on July 3.

"In order to have the engine in Washington and in actual running order at the Nation's capital on Independence Day the perfected engine was sent from a Western city in a special express car. The journey was made in 21 hours, and four young men guarded the engine *en route* to Washington and personally attended to its transfer from one railroad to another.

"With the need for speed as an incentive, tools for building the first engine were made even before the drawings were finished—on the assumption that they would be correct. Parts of the first engine were turned out at 12 different factories, located all the way from Connecticut to California. When the parts were assembled the adjustment was perfect and the performance of the engine was wonderfully gratifying. This in itself demonstrates the capabilities of American factories when put to the test and when thoroughly organised for emergency work of this sort.

"One of the chief rules outlined at the beginning of the designing work was that no engineer should be permitted to introduce construction which had not been read out. There was no time for theorising. The new engine is successful because it embodies the best thought of engineering experience to date. Not only did this country furnish ideas through celebrated consulting engineers, but the representatives in the United States of England, France and Italy co-operated in the development.

"Thirty days after the assembling of the first engine preliminary tests justified the Government in formally accepting the engine as the best aircraft engine produced in any country. The final tests confirmed our faith in every degree. Both the flying and altitude tests of the new engine have been gratifying. One test was conducted at Pikes Peak, where the United States aviation engine performed satisfactorily at this high altitude. One of the engines, in an airplane, broke the American altitude record in a recent flying test.

"While it is not deemed expedient to discuss in detail performances and mechanics, it may be said that standardisation is a chief factor in the development. Cylinders, pistons, and every other part of the engine have been standardised. They may be produced rapidly and economically by a great many factories operating under Government contracts. They may be as rapidly assembled, either by these plants or at a central assembly plant.

"The new engine amounts practically to an international model. It embodies the best that there is in American engineering and the best features of European models, so far as it has been possible to adapt the latter to American manufacturing methods.

"The two engineers more directly connected with the production of the United States aviation engine had before them not only the blue prints and models of the most successful engines the war has produced, but also every available American suggestion. Men skilled in the invention of engines, both automobile and airplane, advised these engineers who were charged with the duty of providing rapidly and unerringly an engine which would embody every essential for war-time use. Non-essential complexities were consistently discarded by these engineers. The result was a composite design of maximum power, minimum weight, great speed capability and adaptability to quick production.

"The standardisation of parts materially simplifies the problem of repair and maintenance. Spare parts will be promptly available at all times. Even the cylinders are designed separately. It is possible to build the new engine in four models, ranging from four to 12 cylinders, and under the standardisation plan now worked out an eight-cylinder or a 12-cylinder model can be made, using the same standard cylinders, pistons, valves, and so on. This will make the question of repairs back of the lines a comparatively simple matter. The parts of the wrecked eight-cylinder or 12-cylinder engines will be interchangeable, and a new engine may be assembled from the parts of wrecked machines.

"The standardisation of the new engine does not mean that there will be no change in it during the war. There will be continuous experimentation as new types and improvements develop at the front and new ideas are born of the war emergency. If the engine can be improved, it will be improved; but as the engine stands to-day it is one of wonderful success and produced under dramatic circumstances.

"Construction of the new standard engine will not interfere with the continued manufacture of other serviceable models, either European or American, which existing plants are already turning out. The production of the United State engine will be carried on almost entirely in a new and expanding industrial field.

"The Government is sometimes asked, 'Why does not the United States adopt one of the successful British or French high-powered machines and manufacture them?' British and French machines, as a rule, are not adapted to American manufacturing methods. They are highly specialised machines requiring much handwork from mechanics who are in fact artisans. It would require a year or more to teach American manufacturers and their mechanics to turn out such highly specialised airplanes. With the completion of the final tests of the engine—tests which satisfied and gratified both expert engineers and Army officers—progress has already been made toward organising industry for the manufacture of the new machines, and deliveries will begin within a comparatively short time."

THE CONSTRUCTION OF MOTOR OMNIBUSES.

The Commissioner of Police of the Metropolis, as the authority for licensing public carriages, issued a notice dated April 3, 1917, with regard to the future construction of motor vehicles intended for licensing as motor omnibuses within the metropolitan area.

As stated in the notice of April, 1917, the present time appears opportune for reviewing licensing requirements, and summarising those deemed of cardinal importance.

It is not proposed to insist upon vehicles of smaller dimensions or with less seating capacity than the existing type. On the other hand, it is not contemplated to agree to any increase in size or in seating capacity, as the existing scale of a maximum of 34 seats best meets London traffic requirements.

It is realised in respect of the weight of the vehicle and weight effect on roads, that improvements may be secured by careful reconsideration of all the details of construction of the chassis, road wheels, power and transmission mechanism, including the use of modern materials of high mechanical properties, and that the reduction thereby effected will compensate for any slight additions of weight needed for the improvement of springs, wheels, &c.

In the Commissioner's opinion, he would be justified in agreeing to some increase of weight in component parts needed to secure improvement in springing and in the wheels, the object aimed at being reduction of impact shock, more especially on damaged road surfaces—but for this increase of weight in certain parts there should be a reduction elsewhere.

In summarising the points of cardinal importance, attention is called to the following :—

1. The seating capacity of the motor omnibus shall be for not more than 34 passengers.

2. The weight shall not be more than 3½ tons unladen, or 6 tons fully laden.

3. The weight must be so distributed that the front wheels are not unduly loaded.

4. The length of the vehicle must not exceed 23 ft.

5. The breadth overall must not exceed 7 ft. 2 in. at any part.

6. Each vehicle must be provided with two effective and independent and independently operative brakes acting on the back wheels.

7. The wheel track should not be less than 5 ft. 6 in. centre to centre of tyres for both front and back wheels.

8. The distance between the outsides of the back springs shall not be less than 45 in., and of the front springs not less than 38 in.

9. The requirements as laid down in the Notice to Proprietors of August, 1909, may be referred to, but the Commissioner does not think it advisable to enter into greater detail lest he should thereby appear to be hampering designers.

The Commissioner invites the co-operation of manufacturers in designing and constructing vehicles which can operate in the streets without affording ground for complaints.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—Much anxiety is being felt by steel-makers and all those engaged in one way or another in the steel-making industry, with regard to future rates and prospects caused mainly by the increased cost of coal—alike for manufacturing and all other purposes—and the recent advance of wages, which means such a very considerable item where large staffs are employed. A definite pronouncement on the subject is being looked for daily, but apparently nothing has been decided so far. Notwithstanding this uncertainty, however, the productive activity remains unabated, and it is with difficulty that manufacturers keep the supply level with the demand, particularly for shipbuilding yards and munitions factories. Shell discard steel is being used in increasing quantity for many Government contracts. In every other particular matters stand just where they did a week ago. For export firm rates are demanded and readily paid for steel bars, ship plates and angles.

Malleable Iron Trade.—The malleable iron trade progresses and prospers, and order books are full to overflowing with work which will take many months to complete. By far the larger proportion of this is for home consumption, and makers have little time for the consideration of any overseas orders or requirements, in consequence shipments are strictly limited. Although an advance in price may be intimated any day, "Crown" bars are still nominally quoted at 16*l.* per ton f.o.b.

Scotch Pig-Iron Trade.—As in every other branch of the steel and iron trade much uncertainty prevails as to what steps Government will take in the way of revising the price of pig-iron, especially as it is some considerable time now since any official readjustment took place. Meantime, the greatest activity prevails, the demand for hematite being as brisk as ever, for the steel works are still abnormally busy and very speedily absorb every ton produced. Forge and foundry iron are also much in demand, excepting where officially fixed prices are all firm, while on shipment orders an advance of from 2*s.* 6*d.* to 5*s.* per ton has already been levied by some makers.

Advance of Ironmoulders' Wages.—A decision has now been made by the Committee on Production regarding the recent demand made by the Associated Ironmoulders of Scotland and the Central Ironmoulders' Association for an advance of wages. The application having been made for 100 per cent.—including advances already made to the extent of 15*s.* per week since the outbreak of war—it has been decided to grant a further increase of 5*s.* per week to all timeworkers of 18 years and over; 2*s.* 6*d.* per week to apprentices, boys and youths under 18 years—this to be increased a further 2*s.* 6*d.* when they attain their eighteenth birthday. In addition to this, an increase of 5*s.* per week, over and above their weekly earnings, will be paid to all pieceworkers and premium-bonus workers, calculated, naturally, on the present basis. Regarded purely as war advances, to meet the exigencies of the times, these changes will take effect as from the first full pay in December.

Development of the Forth Area.—The plan for the development of the Firth of Forth area as a shipbuilding, engineering and general manufacturing centre has now reached a further stage by the issue of a booklet embodying expert reports prepared by men who are thoroughly conversant with every detail relative to the configuration of the entire district and its possibilities. In the opinion of one writer the manufacture of basic steel might be introduced and carried on successfully as a new industry. The information given is all most interesting and most instructive, and worthy the consideration of iron and steel makers and shipbuilders desirous of extending operations. It is proposed to form an Advisory Board run on similar lines to those of the Clyde Trust, an institution which has done an enormous amount of good for Glasgow and the Clyde area.

The Capital of Gas Undertakings.—Mr. Harry Jones, in his presidential address to the Institution of Civil Engineers, delivered on the 6th inst., stated that the average capital employed for 55 of the largest gas undertakings was in the region of 12*s.* 1*d.* per 1,000 cub. ft. for companies, whilst for the corporation undertakings, which had somewhat larger capitals, it was somewhere near 15*s.*, the difference being due to premiums paid on the transfer of the undertakings to local authorities.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—The monthly decline in the traffic dealt with at the Humber port is again recorded for October. The aggregate of 292,364 tons was a decline of 32,006 tons, as compared with the corresponding period of last year. For the present year up to date the total figure is 2,432,096 tons, over a million tons less than in the ten months of 1916. The statistical return is shorn of much of its interest by the continued absence of the figures relating to the exports to foreign countries and the coastwise trade. Denaby and Cadeby Main colliery is still the principal contributor, but its figures again show a falling-off.

South Yorkshire Coal Trade.—There is great activity all round for fuel of any description, the utmost efforts being put forward to supplement whatever stocks are held at the works and railway depots. Agents report that business is becoming more and more of a routine character, thanks to the hundred and one ways in which traffic seems to be controlled or regulated. Open market business has become smaller than ever, and collieries offer little inducement to foster it. There is little doubt that the full attention of the collieries at the present has to be devoted to the fulfilment of contract requirements, and almost the whole of their output goes away automatically and systematically under this head. Government needs for Admiralty and also for Allied Powers require substantial tonnage, which, together with home demands, necessitate pits working at full pressure. Best steam hards are the most wanted grade, but there is not much to choose between them and the smaller sorts. Slacks have recovered their former strength, whilst cokes continue at top value and in big request. The position of householders gives the traders the greatest difficulty in apportioning supplies equitably, for stocks are not equal to the abnormal demand. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* 6*d.* to 15*s.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.* per ton at the pit.

Iron and Steel.—The problem of common irons from the steelmakers point of view is many-sided. In the first place there is the question of a prospective advance in the tariff. On this the Ministry of Munitions has as yet made no definite announcement, and the unsettling effect upon buyers still remains. In some quarters there is a growing feeling that no change will be made, but others hold the view that some intimation on the subject will not be long delayed and that an increase is bound to follow the case made out by the makers, which is based on the greater cost of production, notably the increase in fuel. The point which excites most attention here is not whether there will be an advance or not, but rather the amount of it. This is a matter which affects not only the common iron trade, but also the finished iron, and certain sections of the steel and scrap trades. Any modification in the one is bound to have some effect upon the others. Certain works complain that it is difficult at times to obtain the necessary quantity of pig-iron owing to the transport delays or the insufficiency of the output. These are items which are promised prompt rectification. New steel furnaces have now got into full running order, but the production is yet below the figure required. Open-hearth brands are being chiefly made, but the Bessemer output falls off somewhat as compared with the first half of the present year. Electric-made steel is in urgent demand, whilst a larger quantity of high-speed variety is sold with ease. All export trade in this connection is being drastically tightened up. Little Swedish makes of either iron or steel come forward. In view of the attitude of the labour element in modifying their demand for a war bonus from 20 per cent. to 15 per cent., there is a good prospect of the dispute being satisfactorily settled in the cutlery trade. Women are to benefit by the advance. New Admiralty contracts have just been received. They are of an important character. In the future, War Office and Admiralty cutlery is bound to cost the nation more on account of the increased working expenses of the manufacturers following the rises in wages and materials.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has sent us a copy of a new list (No. 39) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

THE YEAR BOOK OF THE UNIVERSITIES OF THE EMPIRE.—This very useful book gives particulars of 56 universities of the British Empire, with the names and diplomas of all officials, professors, lecturers, together with particulars of changes of staff, benefactions, number of students, degrees conferred, &c. In addition, there are appendices on (1) the Beit Memorial Fellowships for medical research, and for scientific research; (2) scholarships awarded by the Royal Commissioners for the Exhibition of 1851; and (3) the Rhodes scholarships. The previous volume (1915) contained the regulations of the principal technical and scientific institutions. The book is published for the Universities Bureau of the British Empire by Herbert Jenkins, Limited, Arundel-place, Haymarket, London, at the price of 7*s.* 6*d.* net.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business, just now, is very quiet, and a feeling of considerable uncertainty prevails, the question still occupying the minds of traders being whether fixed maximum pig-iron prices will be advanced to cover cost of increased production, or the position will be adjusted by other means. Opinion is much divided on the matter, and an authoritative announcement would be very welcome. There is continued complaint of shortage of trucks, and difficulty is experienced in obtaining delivery of Cleveland pig-iron already arranged for. In some instances makers are having to stock iron as they are unable to get it away. Export trade is more or less stagnant. Shippers are most anxious that any alteration in price decided upon be made known without delay and so minimise difficulties arising in connection with iron expected to be licensed for export in the next day or two. For home consumption, No. 3 Cleveland pig-iron is 92*s.* 6*d.*, and that price also rules for No. 4 foundry and No. 4 forge, whilst No. 1 is 96*s.* 6*d.*; and for shipment to the Allies, No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

Output of Pig-Iron.—A Spiegel furnace has gone out of operation, this reducing for the time being the output of pig-iron. One or two additional furnaces, however, are expected to be started on basic iron very shortly. The number of furnaces blowing on the North-East Coast now stands at 75, of which 34 are making Cleveland pig-iron, 28 are turning out hematite, and 13 are producing Spiegel, basic and other special irons.

Coke.—Home demand for coke is good. The heavy local requirements continue to be met by quite ample supply. Considerable business is reported. Average blast-furnace kinds are 33*s.* at the ovens, and qualities low in phosphorus 35*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Producers of manufactured iron and steel are taxed to their maximum capacity to cope with the heavy Government requirements, and the huge demands of the shipyards. Ordinary commercial business is hardly mentioned. The opinion is freely expressed that there will have to be an all round readjustment of prices. Up to the present, however, the following are still among the principal market quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 19*l.* 10*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 10*l.* 17*s.* 6*d.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

AGRICULTURAL MACHINERY DEMONSTRATION.—A demonstration of farm tractors on a field adjoining the Austin Company's works will take place on the 22nd and 23rd inst. The machines will be shown drawing ploughs and other machinery on the land, driving chaff-cutting, threshing machines, corn crushing, &c. The demonstration is proposed to be the most complete of its kind yet offered as an opportunity of judging the merits of these machines for general farm purposes. The public is cordially invited to make application for tickets, which may be obtained from the Tractor Department, Austin Motor Company, Limited, Northfield, Birmingham, as early as possible, in order that adequate catering and transport facilities may be provided.

THE LATE MR. WILLIAM NEWBOLD BAINES.—We regret to have to record the death of Mr. William Newbold Baines, of "Elsinore," Yeovil, which occurred on the 5th inst., at Edinburgh after a short illness, at the comparatively early age of 54. The deceased gentleman's grandfather was the founder of the firm of W.N. Baines & Co., brassfounders, of Rotherham, and his uncle and father assisted in the development of the business, the latter looking after its interests abroad and particularly in Russia. After serving his apprenticeship with Messrs. Pollock & McNab, of Hyde, Manchester, and spending some time in Germany, in order to learn German, the subject of this brief memoir went through the drawing office of Messrs. Bellino-Fenderich, Odessa, the pioneers, and at that time, the most important of the engineering concerns in South Russia. Mr. Baines subsequently joined his father, who, by then, held several agencies for important Sheffield and other British manufacturers, and when his father died, continued the business on his own account, from time to time extending the scope and range of the agencies, as well as that of the territory covered. Although particularly identified with trade in Russia, he also toured the rest of Europe, and in his long sojourns abroad, acquired an intimate knowledge of the various markets in which he was interested. He was a polyglot linguist, and his personal charm of manner, unfailing tact, great business ability and integrity, not only won him esteem and friendship wherever he went, but assured the success of his missions. He had, of more recent years, become associated in the development in Russia and on the Continent, of the business interests of Messrs. Petters, Ltd., Yeovil, the well-known oil-engine manufacturers, the association culminating some two years ago in his election to a seat on the board of directors of this company. Mr. Baines was an indefatigible, efficient, experienced export representative, and a true and kindly man, who was ever ready to lend a helping hand where needed. Our sympathy is extended to his widow and four children.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Collieries continued working fairly well until Monday, when several stoppages were reported, and during the week the number of idle collieries increased. The collieries have plenty of orders on their books; contracts alone are keeping the pits going; but the congestion of loaded trucks is now almost as great as it was before the recent three-days' strike on the part of the colliery examiners.

Newport.—The enforced diminished output of large coal is re-acting unfavourably on the supply of small coals, and some of the composite undertakings have recently been compelled to buy smalls for the use of their own steel works.

Coal Trimmers and Pooling of Labour.—A scheme of a far-reaching character was recently put forward by the local coal trimmers, with the view of the pooling of labour, whereby it was sought to obviate the possibility of some men working practically full time, while others might be idle half their time. Had the scheme been adopted, it would have meant that instead of being directly engaged by their employers, the coal trimmers Union would be vested with the authority of allocating work by rota to the coal trimmers in the ports of Cardiff, Barry and Penarth. It was foreseen that serious difficulties might arise by the adoption of such a principle, and it is now announced that the members of the Union by a ballot vote have definitely rejected the scheme.

Supplies of Coal to Italy.—As already reported, a new pooling scheme for the supply of coal to Italy was recently agreed upon, the new arrangement to take effect retrospectively as from November 1, 1916. The scheme was intended to cover all shipments beyond the quantity specified for the immediate service of the Italian State authorities, and to remain operative for the duration of the limitation scheme. When the matter was under discussion, difficulties were foreseen over the retrospective application of the agreement, and to meet these difficulties, it was suggested that the scheme should not be brought into operation till next January. The majority representing members who have suffered most from the working of the old regime, insisted on the provision, which was ultimately adopted; but it has now been discovered that this involves the question of the voluntary return from individual firms of a total sum of anything between 35,000*l.* and 40,000*l.* The complaint of colliery owners is that they may suffer for the use made by the Italian Committee of its authority to state what coals shall be shipped for any particular period. This Committee, it is pointed out, can hardly be expected to know all the coals that are marketed at Cardiff, and much less of their trade names, and what is apprehended is that collieries, in individual cases, and particularly those whose outputs are relatively small, and largely interested in mixed cargoes, will be adversely affected to such an extent as to cause them to loose a great deal of their usual business.

Welsh School of Mining.—Principal G. Knox has issued an interesting report relative to the work and programme of the South Wales School of Mines. During the session under review, 137 students were enrolled at the Treforest School, and 82 at Crumlin, making a total of 219. The number of students entering for the full-time course was the smallest since the school commenced. This falling-off, however, is entirely due to the conditions resulting from the war. Principal Knox points out that prospective full-time students are between 17 and 18 years of age, and many of these youths, who would, under ordinary circumstances, have commenced their technical studies during the past session, preferred to undergo a short period of special training at other institutions with the view of joining some special branch of His Majesty's forces when called up for service. The students have made satisfactory progress, both in internal and external examinations, 14 having gained first-class certificates, 13 second-class certificates, and 7 surveyors' certificates in the Home Office examinations during the session.

THE INSTITUTION OF CIVIL ENGINEERS.—The Council of the Institution of Civil Engineers have made the following awards for papers published in the Proceedings without discussion during the session 1916-1917:—A Watt Gold Medal to Major H. S. B. Whitley, R.E. (Neath); Telford Premiums to W. C. Popplewell (Manchester); Herbert Carrington (Woodley, Stockport); Dr. A. A. Stoddard (Bournemouth); A. E. L. Chorlton, C.B.E. (Lincoln); and B. M. Samuelson (Rangoon). The Manby Premium to R. Bleazby (Perth, W.A.). The Webb Prize to J. B. Ball (London). The Howard Quinquennial Prize to Dr. W. C. Unwin, F.R.S.

THE MINISTRY OF MUNITIONS AND AGRICULTURAL MACHINERY.—With a view to removing possible misunderstanding of the functions of the Agricultural Machinery Department of the Ministry of Munitions as regards the supply of agricultural machinery, implements, fuel and accessories, it is to be noted that these functions are confined solely to the carrying out of Government orders for such material received from the Board of Agriculture for England, Scotland and Ireland, the issuing of permits to manufacturers, the control of imports and exports; and to giving general assistance to manufacturers in the execution of their orders, whether Government or private. The supply of the above-mentioned commodities to the consumer, in so far as it is undertaken by the Government, is in the hands of the Food Production Department of the Board of Agriculture, to whom all communications on the subject should be addressed.

THE PAUL GIROD ELECTRIC STEEL FURNACE.

CONSTRUCTED BY THE COMPAGNIE DES FORGES ET ACIÉRIES ÉLECTRIQUES PAUL GIROD, UGINE, SAVOIE, FRANCE.

(*For Description, see Page 519.*)

FIG. 5.

THE 15-CUBIC YARD DIPPER DREDGER CAR

CONSTRUCTED BY THE BUCYRUS COMPAN SOUTH

(For Description Page 5

Fig. 1.

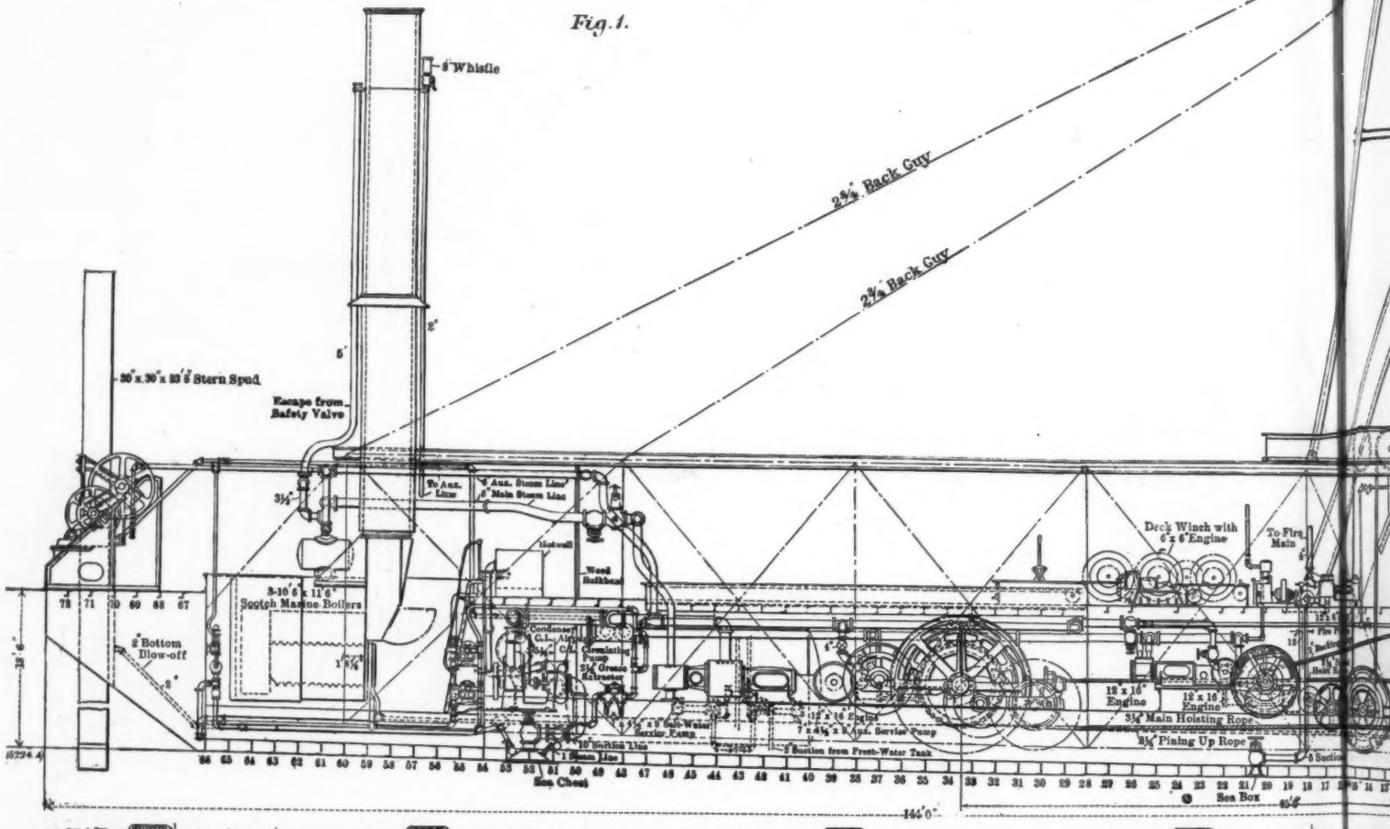
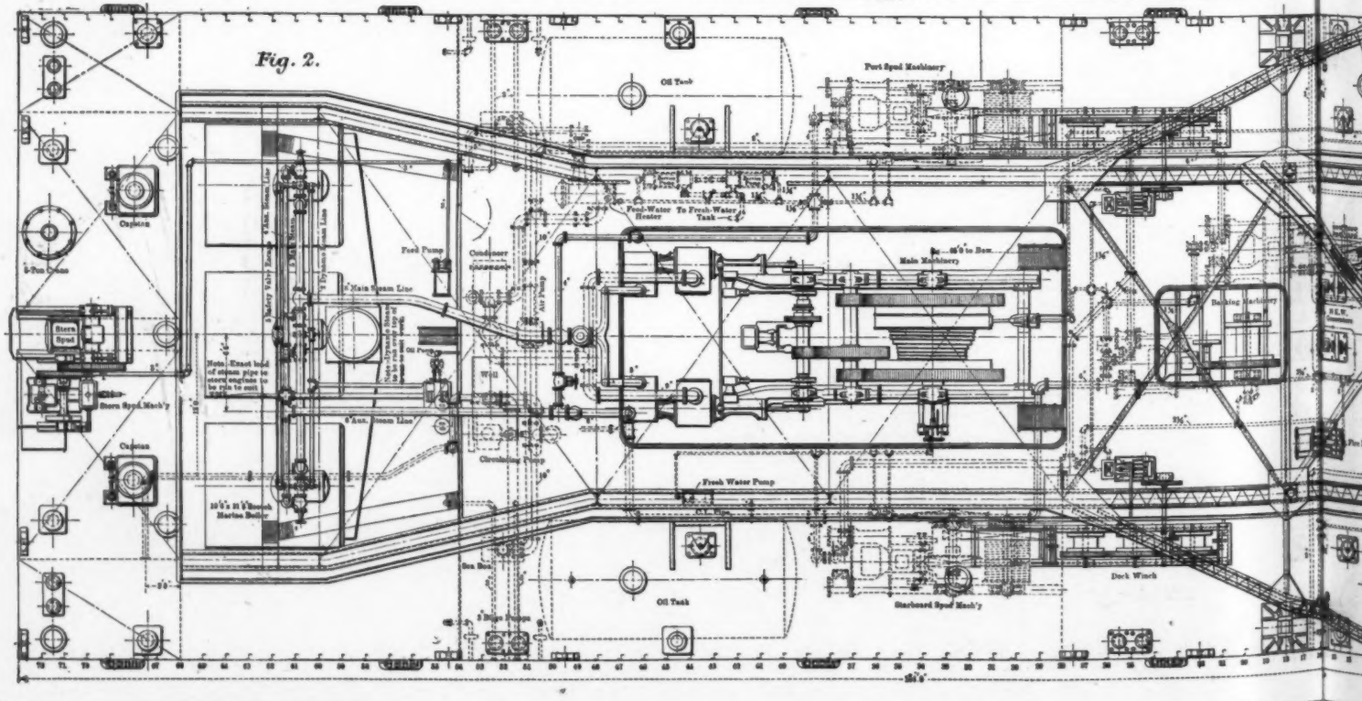


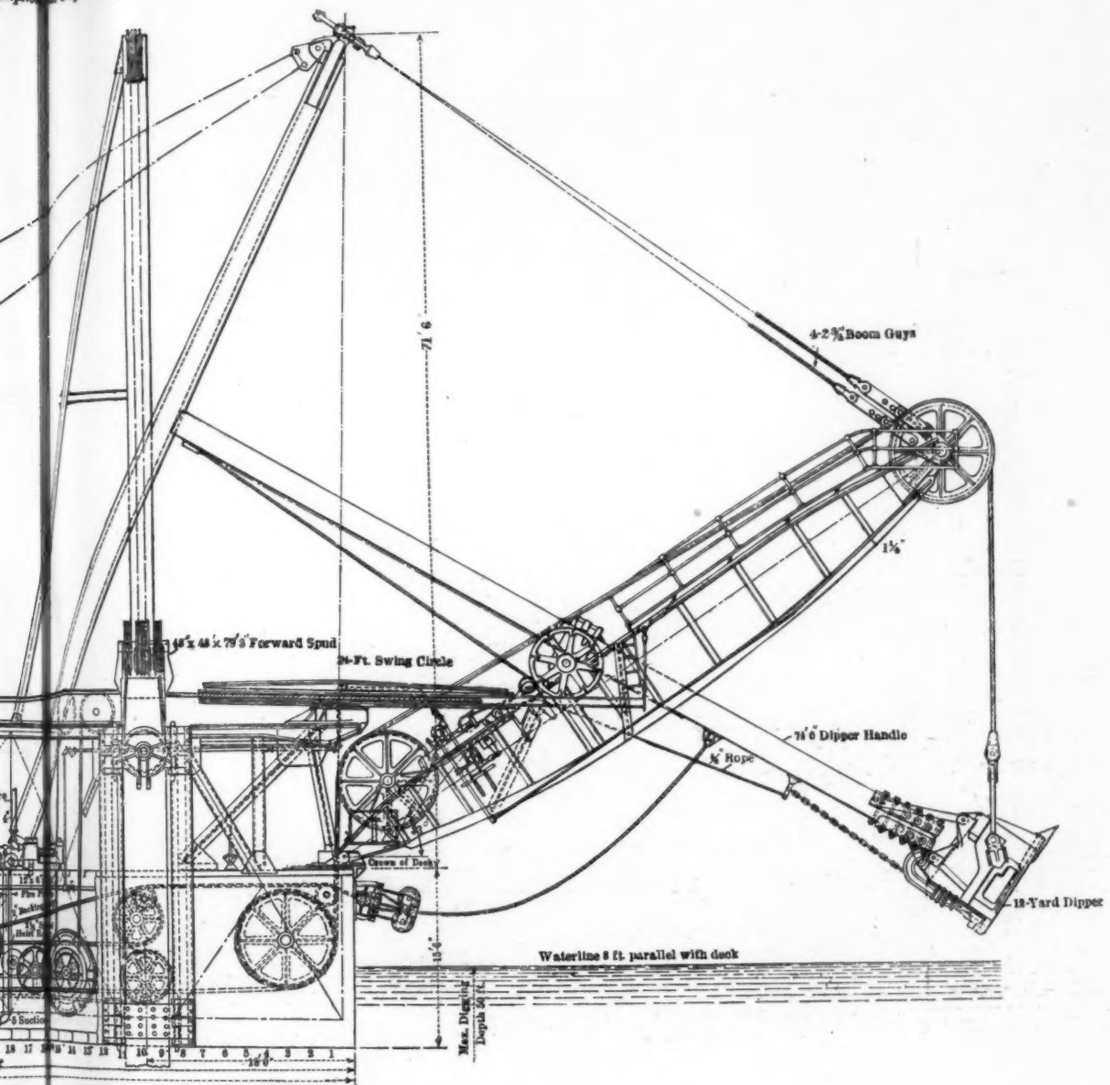
Fig. 2.



CARACAS" FOR THE PANAMA CANAL.

SOUTH MILWAUKEE, WISCONSIN, U.S.A

(See Page 531.)



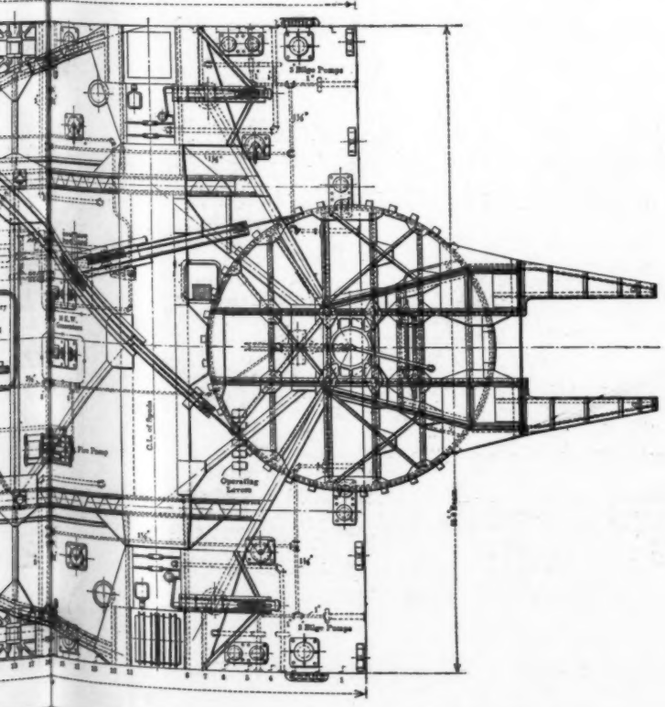
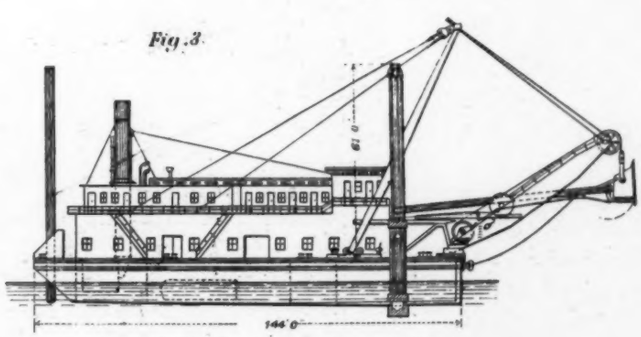


Fig. 3.



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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of a 15-CUBIC YARD DIPPER DREDGER "CARACAS" FOR THE PANAMA CANAL.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 16, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. Paper:—"Some Notes on Air Lift Pumping," by Mr. A W. Purchas, of Wolverhampton, Associate Member.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 16, a meeting will be held at 39, Victoria Street, S.W. 1. "Apprenticeship of Engineers," by Mr. Towse.

THE SOCIETY OF ENGINEERS.—Monday, November 19, at 5 p.m., in the apartments of the Geological Society, Burlington House, Piccadilly, W. A paper, entitled "Sewage and its Precipitation; further Experiments" (postponed from October 1, 1917), will be read by Mr. Reginald Brown, M.Inst.C.E., M.I.Mech.E., F.S.I., F.R.San.I.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, November 20, at 8 p.m., at the House of the Royal Society of Arts, John Street, Adelphi, W.C. 2. The following paper will be read:—"The Oil Prospects of the British Isles," by Mr. W. H. Dalton, F.G.S., F.C.S.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 20, at 5.30 p.m. Paper to be submitted for discussion:—"The Hardinge Bridge over the Lower Ganges at Sara," by Sir Robert Richard Gales, F.C.H., M.Inst.C.E.

THE ROYAL SOCIETY OF ARTS.—Wednesday afternoon, November 21. Opening meeting of the 164th session. Address by Mr. Alan A. Campbell Swinton, F.R.S., Vice-President and Chairman of the Council on "Science and its Functions." The chair will be taken at 4.30 p.m.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, November 21, at 5 p.m., at 70, Victoria Street, Westminster. Papers to be read:—(1) "The Twelve-Hourly Barometer Oscillation," by Mr. G. C. Simpson, D.Sc., F.R.S., F.R.Met.Soc. (2) "Abnormal Temperature, with special reference to the Daily Maximum Air Temperature at Greenwich," by Mr. W. W. Bryant, B.A., F.R.Met.Soc.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 21, at 8 p.m., at the Royal Institution, Colquitt Street, when a paper will be read by Mr. J. B. C. Kershaw, F.I.C., F.S.S., entitled "The Conservation of our Fuel Reserves by the Use of Low-Grade Fuels for Power Generation."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 22, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster, S.W. "Gas-Firing Boilers," by Mr. T. M. Hunter, M.A., B.Sc.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Saturday, November 24, at 2.30 p.m., at Caxton Hall, Westminster, when Mr. J. Maxwell Dunn, Graduate, L. and N.W. Railway, will read a paper on "Locomotive Blast Pipes and Chimneys."

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, NOVEMBER 16, 1917.

RÖNTGEN RAYS AND THE WAR.

A PRESIDENT of the Röntgen Society, a society which, from the first, has consisted half of medical men and half of scientific laymen of widely differing interests, has not an easy task in his address. When Captain G. W. C. Kaye, D.Sc., of the London Electrical Engineers, delivered his address on November 5—the twentieth anniversary of the society's birth fell on the 6th—he reversed in a certain sense the title he had himself chosen, "X-rays and the War." That is to say, he devoted the first part of his discourse to the humanitarian side of his problems, the veritable triumphs that have been achieved by the aid of the rays during the war. The rays themselves, the physical side of the problems, were the subject of the second part, to which we shall practically have to confine ourselves. Before the war broke out Dr. Kaye was working in the heat and radium divisions of the National Physical Laboratory, and his name has often been mentioned in our columns in this connection, notably with respect to thermoionic currents, to which reference is made in this article.

In a soldier's life, Captain Kaye pointed out, the use of X-rays begins early. The category of the recruit is settled by their aid, and the malingerer is set back by them; the wounded soldier now leaves the hospital a "grouser," with a sense of injustice rankling within him, if his "picture" should not have been taken. The rays reveal the spot and source of his pains and follow a wound through all its stages; they measure the location of a foreign substance in the eyeball within a hundredth of an inch; they diagnose incipient tuberculosis and internal diseases, and the dental radiologist traces throat and digestive troubles back to septic poisoning by decayed teeth; finally the rays give valuable help in repairing the defects they have disclosed, including soldier's heart. Ionisation and other more or less electric treatments do their share in the cure, of course; but in the glorious story of modern methods of re-establishing shattered and mutilated humanity the X-rays take the lead, and Captain Kaye was able to refer to many signal services rendered by several members of his society.

We pass with Captain Kaye to the technical and physical aspects of X-ray problems. The outbreak of the war, he said, found the bulb manufacturer deprived of the German bulb glass; the State had stepped in there, but the report of the X-ray Committee had not yet been published. Though tubes differed much in detail, the general design of the target tube had little changed, and all X-ray tubes were extraordinarily inefficient things; hardly one-thousandth of the energy imparted to the kathode rays was utilised. Nearly all the peculiarities of the tubes were due to never-ending variations of the gas pressure produced by local emission and absorption of gas by the electrodes and glass. For a definite load the self-adjustment might be complete; a slight alteration of the conditions would make the tube cranky. The space and surface electrification depending upon the disposition of the kathode were also important. Coolidge had achieved a great advance by reducing the gas pressure to less than one-twentieth of its usual amount; as a consequence, no discharge would pass until a hot wire kathode was added to the tube. Some wonderful results had been obtained by Coolidge with experimental water-cooled models; one tube was run continuously for many hours at 200 milliamperes and 70,000 volts, *i.e.*, 14 kw., and that figure was to be raised to 50 kw. But Coolidge tube rays were no more homogeneous than those from other bulbs, and the hope of producing X-rays approximating the hardest γ-rays had not been realised. Rutherford had found the reason recently. He had worked a Coolidge tube at 200,000 volts—very near its safety limit—and had filtered the rays through 1 cm. of lead, thereby reducing their intensity more than a million-fold. The residual rays were practically homogeneous of about 0.06 Angström unit, A.U. But the hardest γ-rays from radium C ranged from 0.02 A.U. to 0.007 A.U., and would require tubes at 600,000 volts and 2,000,000 volts for their generation. So we had a long way yet to go before we could imitate the processes within the radium atom.

The rays from an X-ray bulb were amazingly complicated, yet consisted of two general groups: (*a*) a continuous spectrum of rays with a sharply-defined boundary on the side of short wave-lengths; the position of that boundary depending upon the volts; (*b*) one or more radiations (of the J, K, L, M . . . series), each approximately homogeneous and characteristic of the metal of the antikathode; the higher the atomic weight of that metal, the more penetrating the radiation in the same series. The proportions of *a* and *b* depend on the conditions; with very soft tubes a large proportion of the radiation might be wholly characteristic. Dr. Kaye himself had experimented on the proportion by progressive filtration before the war. As regards the spectrum of the general rays, the maximum frequency (hardness) of rays could be calculated by Einstein's extension of Planck's quantum theory: $Ve = h\nu$, where V was the voltage, e the elementary charge on each kathode ray, h Planck's constant, and ν the frequency of the hardest rays produced. Thus the wave-length of the X-rays was inversely proportional to the volts, and as e and h were known, the frequency of the hardest ν-rays, generated at given volts, could be calculated. Accepting Millikan's values of the constants, the relation was: Wave-length in A.U. = 12,400/voltage; the result was independent of the material of the antikathode. The large admixture of many longer waves with the Einstein rays was due to a number of secondary

causes. Each of the characteristic radiations consisted of a number of spectral lines, for which Einstein's law did not hold; a greater voltage was required for their generation, and Webster had noticed that the various lines of a series all sprang into being together as the volts were raised.

The medical man demanded of the physicist homogeneous rays of the right quality. The task was as difficult as the corresponding problem in visible light. It had been hoped that running a bulb at constant volts—and not at the intermittent potential of an induction coil—would yield monochromatic rays; but the composition of the rays remained the same, unfortunately. There was a gleam of hope, however. To generate a characteristic radiation required a minimum potential and, when that radiation was produced, the rest of the spectrum was enfeebled, while the tube become more efficient from the energy point of view. In other words, when the volts were raised through the critical value, the tube increased in efficiency and began to emit a considerable proportion of homogeneous rays. The softer rays could be filtered out by metal screens; to ensure homogeneity, therefore, one should apply that voltage and screen out softer rays. A suitable antikathode had to be selected. For radiography the K radiations of the heaviest metals (tungsten, platinum, uranium) were sufficiently hard with volts ranging from 80,000 to 160,000. For softer rays antikathodes of lower atomic weight were advisable; if harder rays were required, one should not increase the volts, as that would chiefly strengthen the general spectrum, but rather take another antikathode of greater atomic weight. Thus the worker should be provided with a battery of tubes (probably of the Coolidge type), each with a different antikathode metal, and each labelled with the appropriate voltage for exciting the useful characteristic radiation and with the nature and thickness of the suitable absorbing screens. With targets of medium atomic weights, Dr. Kaye had by these means realised a homogeneity of 90 per cent. The heterogeneity of the rays in ordinary practice was chiefly responsible for the complexity of the dosage problem in radiotherapy. All the dose-meters available displayed selective absorption, and were merely rough guides calculated to reassure the patient rather than the doctor. For most cases it would be best to watch both the voltmeter and milliampere meter.

Proceeding to the part played by X-rays in molecular physics, Dr. Kaye commented upon the work of Laue, Bragg and others on crystal structure and on the importance of Moseley's atomic numbers. Those numbers undoubtedly represented some fundamental attribute of the atom. The atom probably consisted of a concentrated nucleus round which rings of electrons circulated. The nucleus contained both positive and negative electrons, but there was an excess number of positive charges equal to the number of electrons in the rings, the whole atom thus being neutral. Now several quite different methods of experimental attacks indicated that the atomic number equalled the excess number of positive charges in the nucleus. The element was hence more characteristically defined by features depending upon the nucleus of the atom than by the atom itself. The complicated character which X-ray spectroscopy had assumed might have disappointed those who, flushed with Moseley's early triumphs, had hoped to see molecular secrets at last revealed. Yet great progress had been made. The absorption of X-rays (de Broglie) increased markedly as soon as the characteristic radiation was generated; the change was very sudden, and the study of the absorption-bands on the photographs of rays passing through metal plates was very promising.

The boundaries of the general spectrum had been much extended during the last few years. On the ultraviolet side the Schumann and Lyman rays, going down to 500 A.U. (sodium light 5896 A.U.), had been extended by Richardson and Bazzoni to 420 A.U., whilst the longest X-rays of Siegbahn had a wave-length of 12 A.U., and the hardest γ-rays of Rutherford measured about 0.01 A.U. Thus a range of over ten octaves of X and γ rays had been explored without a break—not a bad record for so young a science—but there remained unexplored five octaves between X-rays and ultraviolet light; that range would contain the characteristic X-rays of the light elements from hydrogen and neon. Visible light rays had little penetrative power for "opaque" solids, but they—and red light in particular—penetrated to enormous distances through air and ordinary gases. As we passed beyond the ultraviolet this penetrating power was lost, Lyman rays being very strongly absorbed by gases. That applied also to the other end of the unknown region just mentioned; in long-wave X-ray work vacuum spectrometers were needed. As the wave-lengths further diminished, however, the penetrating power was re-acquired, and for all media now, not only for gases; the hardest γ-rays would pass through anything. In the unknown region we passed from an atomic to a corpuscular absorption, and we could only hope that the whole of this region would be surveyed in the near future.

Dr. Kaye's concluding remarks were devoted to the neglect of science in this country; to the belated recognition of the fact that our system of education misdirected much genius into unproductive channels, and to the value of purely unrestricted and unprescribed research. Dr. Kaye quoted an apt remark by Sir J. J. Thomson in this connection: "The discoveries in applied science may produce a reformation; those in pure science lead to revolutions," and referred to the achievements of the "ionic school" in exemplification of the value of a line of research which, ten years ago, was still considered speculative and theoretical to a degree. Radium-paint dials, high-potential rectifiers, thermoionic detectors—invaluable in radiotelegraphy and radiotelephony—X-ray examination of metals (a radiograph of a steel plate, 1 in. in thickness, was one of the exhibits) the half-watt lamp and the pointolite lamp, the triumphs of radium-therapy—all these were the outcome of such research. In this sense Dr. Kaye finally pleaded for the foundation in London of a Central Institute of Radiology; the first steps toward such an Institute have, we are glad to learn, already been taken.

STATE WATER POWER IN SWEDEN.

Some neutral countries, such as Scandinavia, and Switzerland are practically dependent on one or other of the belligerents for coal. Unfortunately for them coal is one of the essentials of munition making, and the claims of friendship, or of old standing business relations, cannot be listened to until all the home requirements have been fulfilled. Hence a coal famine has arisen in some countries, with the result that all other sources of motive power are being eagerly utilised. It was fortunate for Sweden that previous to the war active steps were taken to utilise some of the abundant water power of the country, and that several large stations were sufficiently advanced a year or two ago to supply current over a considerable area. These stations are now overloaded, and plans are being got out for their immediate extension.

In the Trollhätta* district there is an exceedingly active demand for electric current; the Trollhätta State power station can at present, when all units are fully loaded, supply a maximum of 68,000 kw., and the present demand is so great, that no contracts for additional supplies can be undertaken. The extension of the power station, which is now progressing, should result in the number of units being increased from 8 to 13, but until the Vänern has been regulated, no more than 12 can be worked on account of an insufficiency of water. The number of applicants for power, however, is so great, that the third section of the works now being constructed, is practically taken up.

The Alfkarleby† State Power Station is already so heavily loaded, that in the northern and southern outskirts of its vast distribution area further supply will soon be needed beyond that which can be derived from the steam central reserve station which has just been built at Västeros. There will soon be need for new power stations in this district, and as the State owns water power at Motola, it seems a little inconsistent to draw energy from the heavily-taxed Alfkarleby station to that locality.

A still greater problem will also soon call for solution, viz., a supply of sufficient energy for the chemical industry. As the water power of central Sweden is intended to be reserved as much as possible for other industries and for more general purposes, the chemical industry may have to go further north.

As regards the Trollhätta State Power Station it is stated that the pending extensions, that is the third section, were commenced in 1915 and two of the five new units are expected to be ready this year. When completed the total capacity will be 130,000 turbine h.p. So far 580,000*l.* have been voted for this third section, including a grant of 83,000*l.* on account of the high prices prevailing. The constant rise in the price of building material and more especially of machinery will call for a further vote of 67,000*l.* The Royal Waterfalls Board further asks for a grant of 280,000*l.* for a new (the fourth) State hydro-electric station at Lilla Edet, also on the Göta river, but lower than Trollhätta. The first section of the Lilla Edet installation was estimated before the war to entail an expenditure of about 350,000*l.*, of which total a first instalment of 150,000*l.* is now being asked for, but owing to the rise in the cost of construction 130,000*l.* additional will be needed, swelling the former amount to 280,000*l.* Even if the same increase in cost should extend over the whole period of construction, the Board thinks the work should be forthwith proceeded with, and there is, of course, a chance of prices somewhat giving in in the course of the three or four years the building of the power station will require. As to the price for electric energy four years hence, it is not possible to make anything like an accurate forecast, but it may in any case be expected to keep pace with the fall in the value of money.

For the steam control station of Västeras, which is a reserve to the Alfkarleby hydro-electric power station 175,000*l.* have so far been voted, the plan comprising three units of an aggregate normal capacity of 20,000 kw. and maximum capacity of 28,000 kw., and boilers for 18,000, to 22,000 kw. Two of the three turbines have been installed, each of 5,000 kw. normally; a third unit and boilers for 10,000 kw. have been ordered. Owing to the rapid increase in the load at the Alfkarleby Station and so as to exploit fully the high water periods and increase the power, it will probably be necessary to have an increased reserve available at Västeras during the year 1921, for which purpose 83,000*l.* are asked for the instalment of additional plant in the building already erected.

The Porjus State* hydro-electric power station at present contains two one-phase units, for railway traffic, each of about 8,500 kw. and a three-phase unit for industrial purposes, of a maximum capacity of about 10,000 kw. and a reserve unit, jointly for both phases. There is space for a fifth unit, and last Riksdag voted the necessary grant for the installation of a fifth unit, three phase, for industrial purposes. A further vote was granted towards a sixth unit or rather turbine, viz., 53,000*l.*, but the money for the generator was not asked for. A vote of 56,000*l.* sterling is now asked for in three-phase generator. As, however, the demand for electric energy within northern Sweden has been very active of late, the Royal Waterfalls Board recommends further exploitation of State water power in the Lule river, and next year will ask for a vote of 165,000*l.*

With reference to this year's Riksdag's vote of 280,000*l.*, for the purchase by the State of water power, in private possession in the Motala river, between Vättera and Boren, and elsewhere the Board is preparing further plans in addition to those in connection with the Tyttbo fall.

The aggregate vote for distribution installations at the State hydro-electric power stations amounts to a sum of 1,280,000*l.*, of which some 1,170,000*l.* will have been expended at the conclusion of the present year. In the aggregate the votes asked for amount to the substantial figure of 11,600,000*l.*, but

* See Engineering, vol. lxxxv, pages 58, 235; vol. lxxxvi, page 816; vol. lxxxvii, page 829; vol. lxxxviii, page 589; vol. xci, pages 778, 811, 816; vol. xcii, page 374; vol. xciii, page 21; vol. cii, page 562.

† See Engineering, vol. cii, pages 29, 51, 171, 563.

* See Engineering, vol. c, pages 385, 411, 435, and vol. cii, page 562.

the Legislative has always dealt liberally with the Royal Waterfall Board, and has never repented doing so.

GOVERNMENT CONTROL OF MANUFACTURE IN GERMANY.

THERE is a tradition in this country that the German people accept the interference and control of the Government with perfect docility and submission. There is, no doubt, much truth in the idea, but recent evidence shows that resentment, if not resistance, has lately been manifest at the high-handed way with which the Government has dragooned some of the leading manufactures. In previous issues we have related the proceedings in connection with the renewal of the Rhenish-Westphalian Coal Syndicate, one of the most important in the country. The term for which it had been created was about to expire, and, owing to the war, some important members were disinclined to assist in its renewal. They probably believed that their interests could be better served if they had greater freedom of action. They were given to understand, however, that if the members could not settle among themselves to renew the agreement the Government would interfere and would create a so-called "coercive syndicate," in which it was recognised there would be much less freedom of action than in the expiring body. The threat was sufficient, and the recalcitrant members hastened to renew their membership. In some other cases, however, less ceremony was observed by the authorities, and both the soap and the shoe manufacturing industries have been gathered into coercive syndicates with very little regard to their wishes.

That the discontent is serious in Germany is shown by a recent debate in the Reichstag, in which both the malcontents and the Government set forth their views with considerable frankness. On behalf of the manufacturers it was urged that the manner in which they had been treated gave cause for serious misgivings. The auxiliary advisory board which they were permitted to form was only ornamental, the provincial companies had no right of decision, the power resting entirely with the controlling board. The members of that board were not the proper representatives of the concerns interested, but were appointed by the Chancellor. From the debate it appears that the Imperial Commissioner has complete authority, and that the danger exists of an industry in one district being drained of all its blood while that in another may be greatly favoured. It is the smaller manufacturers who are the sufferers, while the large concerns become still larger. When normal conditions again prevail the small people and the medium people will find themselves without their staffs and without their plant. The dissolution of the coercive syndicates rests with the Chancellor, and anxiety is felt regarding his intentions for the future. It is asked how long will the new arrangement be continued after the war, and whether plans for increased taxation are not the reason for the present arrangements. For the heavy industries (that is especially iron and coal) the creation of syndicates is regarded as the natural course, whilst it may simply kill the refining and finished products industry. Strenuous demand is made for a guarantee that these coercive measures shall cease with the end of the war.

It fell to the late Vice-Chancellor, Dr. v. Helfferich, to reply to these charges, and he pointed out that the syndicates were measures of necessity, which in themselves were undesirable and which would be done away with as soon as possible. He added that much of the present development must remain—for instance, the close co-operation between the State authorities and the moving forces of industry—but he admitted that the principle must not be carried too far, or the result would be a national industrial machine which would lack the moving power of private initiative. The misgivings expressed were, he said, not justified. The caution with which the Government worked was evidenced by the fact that coercive syndicates had only been decreed in two branches; in others they were feeling their way. What, he asked, would have happened in the soap and shoe industries without State interference? The competition for the raw materials would have ruined the smaller concerns. Without a certain amount of coercion the opposition could not have been overcome. Of course those who were allowed to go on working were in a better position than those who had to stop, but it had been necessary to interfere in a forcible manner. It may be well to add that under the coercive syndicate arrangement a profit of 25 per cent. gross is reserved for the retailer, 10 per cent. for the wholesale dealer, and 6 per cent. for the syndicate concerns.

Of course a Minister always gets the best of it in a Parliamentary debate, as he can plead the safety of the State as against the interest of individuals, but if proof were needed that the coercive syndicalist movement is anything but popular, such proof was afforded by two influential meetings held in Berlin on October 8 and 10 respectively, at the instance of the Hansabund and the Union for the Advancement of German Industrial and Commercial Interests Abroad, at both of which meetings a number of high officials were present. It was urged that after the termination of the war industry and commerce must as soon as possible regain their full former liberty by all official interference being withdrawn. Some apprehension was expressed at the connection between the traditions of the semi-socialistic state of Frederick the Great and the State-socialistic ideas which for decades had been instilled into German students. Under coercive syndicates there could be no industrial self-management, all the important functions having been vested in the control committee appointed by the Chancellor. Commerce must denounce all State monopolies, and the reconstruction period must be made as short as possible. State interference must be confined principally to the question of the foreign exchanges, A resolution was passed to the effect that State interference must be reduced to the utmost during the reconstruction period, and then entirely done away with. All laying idle and combining of concerns, the drawbacks of which even during the war had far outweighed the expected advantages, must as quickly as possible be done away with, and steps must be promptly taken to restore to the concerns coerced into idleness full freedom of working and full capacity for competition.

In addition to coercive syndicates, State monopolies are likely to come into operation before long, and one State monopoly, that of shipping, has already been freely discussed, most divergent views having been uttered. It has been urged in Germany against this State monopoly that the privately managed shipping worked satisfactorily up to the time of the war, and that a State monopoly of such an international nature as merchant shipping might lead to diplomatic complications, apart from presenting great difficulties in the matter of remunerative and satisfactory working. In favour of a State monopoly it is pointed out that such an arrangement probably would result in a corresponding profit for the Exchequer similar to that accruing from the State railways. The cost of the State taking over the merchant shipping is not expected to much exceed 2,000,000,000 marks, which is not looked upon as an insurmountable hindrance. There exists, and has, as a matter of fact, already for a long time existed, a shipping monopoly, and it is now a question of breaking the power of this trust and transferring it to the State.

The proposal of a German Imperial line has been put forward, and it is urged that it would be preferable for the State to take over a concern which owned both steamer lines, shipyards, iron works and coal mines, so that the State should become independent of all groups of capitalists. The company which best answers this demand is the North German Lloyd in Bremen, which, besides its large fleet, has its own docks, large repair shops and, partly at least, also coalfields. It has no building-yard, but the State could take over a couple of Weser yards. The State line would be worked in close connection with the State railways. The capital required in the first instance is calculated at 450,000,000–500,000,000 marks, the State to take over shares and debentures in exchange for State bonds, on which the interest to the shareholders should be the average of the dividends for the last ten years.

It remains to be seen what will be the effect of the present agitation. We hear that the results of State control in Germany have not been satisfactory, and the present movement bears out the rumour very plainly. At the same time the State, like all other belligerents, will need new sources of income, and the idea of monopolies will recommend itself to the bureaucratic mind. Without a better knowledge of the internal condition of Germany it is quite unsafe to prophesy what will follow the war, but we may at least be certain that Germany will not err on the side of individualism.

NOTES.

WEAR IN BIG GUNS.

IN the current number of *Arms and Explosives*, Major T. G. Tulloch (late R.A.) gives an article of much interest at the present time dealing with the wear of large guns. As the author points out, the wear of such guns has a most important influence on the cost of the war, not only on account of the expense of effecting repairs but because such wear leads to inaccuracy of fire and so increases the amount of ammunition expended to attain a definite objective. On this point he says, "In short, if a few thousandths of an inch of steel at the commencement of the rifling of guns, &c., could be prevented from wearing away in so short a time as at present, the reduction in the cost of the war, so far as guns, ammunition, transport, &c., are concerned, is almost incalculable." In dealing with this matter, Major Tulloch differentiates between the damage to the bore near the breech end—damage for which he retains the usual term "corrosion"—and that near the muzzle which he prefers to call "erosion" as it is a purely mechanical effect. The causes which produce the first-named class of damage are complex, and include the effects of temperature, the form and dimensions of the powder chamber, the chemical and physical qualities of the powder used, the weight of charge and rapidity of fire, the gas escape past the projectile, and the composition and physical properties of the steel used for the inner tubes of the gun. All these matters present many points of interest and they are discussed clearly in the article with which we are dealing. Major Tulloch attaches much importance to the evolution of methods for securing the effective sealing of the gas escape immediately after the firing of the charge, and he makes some suggestions as to the lines on which such a device may be designed. As regards the physical properties of the steel used for the inner tube, Major Tulloch considers that the heat treatment should be subject to the analysis of the steel and the forging effect, and he urges the necessity of obtaining more effective forging of the portion of the tube forming the bore, and suggests certain methods of securing this result. With regard to the erosion near the muzzle due to frictional wear and metallic fouling, it is pointed out that to secure good shooting it is desirable to prevent such fouling by all practicable means, such as slightly bell-mouthing the bore, and, as indicative of the importance of this matter, he states that by electrolytic methods over 15 lb. weight of copper have been removed from the bore of an 8-in. gun after firing just over 100 rounds. In concluding his most interesting article, Major Tulloch remarks that it was written to invite discussion and to call attention to certain matters requiring systematic investigation, and we much hope that it may have this result.

PYRITES FROM COAL.

The iron sulphide FeS_2, known as pyrites, marcasite, and under other names, and as a raw material for the manufacture of sulphur and sulphuric acid, occurs as such and associated with other minerals in thick layers, and is a common, but generally unwelcome companion of our coal, in which it is found in brass-coloured streaks, nodules and thin flakes. Much of that pyrites goes on the waste heap. The clean separation of the coal from the mineral is generally too troublesome, so that neither the sulphate, nor the coal adhering to it, are utilized. The war may limit that waste. Before the war ships returning to the United States from Spain

annually brought about 1,000,000 long tons of pyrites as ballast over to America. In 1915 that figure was 964,634 tons, while the production of pyrites in the United States amounted to 394,124 long tons, the latter figure representing 29 per cent. of the consumption. By July, 1917, a clean pyrites was worth three and four times as much as the coal with which it occurred, and the Mining Department of the University of Illinois had demonstrated that the recovery of pyrites from coal was commercially quite feasible, at any rate under something like actual market conditions. The State of Illinois is credited with 14,849 tons of the above-mentioned 394,124 tons of pyrites, and all that pyrites came from the bituminous coal of the State. This coal contains from 1 per cent. to 6 per cent. of sulphur, mostly in the form of pyrites, the rest as gypsum or in organic compounds. Big lumps of pyrites, several feet long and inches thick, are not frequent; but there are smaller lumps which, if they could be freed of the coal adhering to the mineral and embedded in it, might be utilised, and the experiments described by Mr. E. A. Holbrook in Circular No. 5 of the Engineering Experiment Station, University of Illinois, on "The Utilisation of Pyrites occurring in Illinois Bituminous Coal," show that the recovery can be effected on commercial lines. The term "experiments" is hardly correct; for the work was not on a laboratory scale, but was carried out with tons of material in the mining laboratory of the university, which is equipped with machines of industrial type and half industrial dimensions. About 81 per cent. of the total pyrites contents of the coal were isolated by an ordinary ore-dressing process, and by recrushing the middlings this percentage could be raised to 87. The material received contained about 28 per cent. of sulphur, or half its weight of pyrites, the other half being coal. The material had been hand-picked at a tipple preparing No. 7 coal in the Danville district. It was put through Gates or Blake rock breakers, ordinary coal-crushing machinery being unsuitable for the hard pyrites; the coal tended to split from the mineral, which separated in flat pieces, and to break up into cubical pieces. The crushed pyrites was passed through a rotating drum with a perforated shell, provided with 1¼-in. round holes and, on the inside, with lifter shelves; a second drum had ¼-in. holes. The further treatment was in Harz-Luhrig plunger jigs and on Wilfley tables; the density of pyrites ranges from 4.7 to 5.1, that of coal is 1.3. The settling of the water, slimy with coal and clay, &c., was hastened in a Dorr continuous thickener, a cylindrical tank, in the lower part of which a spider rotates, this spider being built up of several arms set with boards in step fashion: the main object of this treatment was to make the water fit for further use again. The coal recovered contained about 8 per cent. of sulphur, the sludge was too impure for use; the coal loss was also about 8 per cent. On the strength of these experiments a plant was designed, and the design submitted to the Allis-Chalmers Manufacturing Company for drawing up a cost estimate, which seems to justify the combination of several small collieries for a common pyrites recovery plant. It should be noted that the Illinois coal pyrites is free from arsenic and antimony.

LITERATURE.

Excess Profits (including Excess Mineral Rights) Duty and Levies under the Munition of War Acts, incorporating the Provisions of the Income Tax Acts made applicable by Statute and by Regulation, also the Regulations of the Commissioners of Inland Revenue and of the Minister of Munitions. By W. E. Snelling, of the Inland Revenue Department. Second Edition, revised and enlarged. London: Sir Isaac Pitman and Sons, Limited. [Price 10*s.* 6*d.* net.]

This is not a book that one would sit down to read with an expectation of keen enjoyment. Its study is a necessary and onerous task, imposed on those who want to know their legal obligations and are prepared to meet them justly. But the most determined inquirer will have to wrestle with difficulties of no common order. The language and phraseology of Acts of Parliament will be found to be repellent in style, and, to the uninitiated, diffuse in construction. Those, unaccustomed to the cumbrous manner in which the subject is approached, and inappreciative of the extreme caution that compels the introduction of long parentheses, will usually find that they have to read a clause twice and construe it very carefully before they can be sure of having detected its subtleties and grasped its purpose. Such a leisurely process is apt to become irritating when repeated indefinitely. Opening the book at random, we come on such a clause as the following, which may serve as an illustration:—"Any deduction allowed for the remuneration of directors, managers and persons concerned in the management of the trade or business shall not, unless the Commissioners of Inland Revenue, owing to any special circumstances or to the fact that the remuneration of any managers or managing directors depends on the profit of the trade or business, otherwise direct, exceed the sums allowed for those purposes in the last pre-war trade year or a proportionate part thereof as the case requires." This sentence, when taken to pieces, conveys a very clear and distinct injunction, but time is required to penetrate the verbiage and get at the central idea. This is precisely the service our friend and mentor renders us and a long-suffering public. Trained in legal conventions and forms, and gifted with special acuteness and an almost uncanny conception of the intentions of our legislators, he is able to translate the most subtle and involved passages into an easily intelligible form, that provides a clue for solving the most ingenious enigmas and avoiding the artful pitfalls that the Act offers to the unwary.

The author's aim is to explain and make intelligible "the most intricate of existing taxing enactments," whose provisions impose a levy of unprecedented severity. The intricacy arises on two grounds. First, from the difficulty of making a fair comparison between normal (peace) profits and current (war) profits; and secondly from the elasticity which the legislature has purposely sanctioned in indicating the methods for computing the taxable excess. Rules are provided for general guidance, but a machinery is set up for the modification of these rules where they press unfairly owing to the operation of particular circumstances whose influence could not be adequately judged. The income-tax procedure is not a model of perfection, but the experience of seventy years and the advice of many masters of finance have been employed in whittling away its worst inequalities of incidence. The Excess Profit Duty is a brand-new Act, that has passed through no such searching examination and amendment, and in the Courts created *ad hoc* the administrators and appellants are alike uncertain of its operation in particular cases. The explanation of the procedure to be followed under all the varying trading processes that promote profits is therefore of the utmost importance, and Mr. Snelling has earned the thanks of accountants and employers of labour for the thorough and clear manner in which he has expounded the Act. By his connection with the Inland Revenue Office he is well equipped for the task he has undertaken, but he is careful to explain that he is personally, and not officially, responsible for the construction he has put on doubtful points on which no authoritative judgment has been given.

The plan adopted consists in summarising the involved phraseology of the clauses in simple language, giving at the same time the actual words of the Act for the benefit of those who are professionally interested. A comprehensive and clear insight into the working of the Act can be obtained by confining attention to this summary, printed in faced type. Pertinent comment and efficient analysis accompany this simplifying process, and further to make the intention of the Act even clearer, typical examples and balance sheets are worked out that should enable the business man to submit a statement with the minimum of trouble. In addition, all the material points are collected into a few pages, with convenient references to the chapters in which the details will be found.

Those who have to submit a statement know perfectly well that the Finance Acts affect all business profits made during the period of the war that exceed by 200*l.* the annual profit made in a pre-war period. After deducting 200*l.* from the net profit, one-half of the remainder has to be paid into the Treasury in the first year the levy is made, and 60 per cent. in any subsequent year. To secure this end, the necessity of any elaborate machinery may not be apparent, but the ingenuity exhibited in the employment of capital, and the variety of sources from which income is drawn, compel the introduction of many safeguards to prevent commercial enterprise being unduly hampered by too stringent restrictions. For example, in newly established businesses no pre-war profits may have accrued, and other tests for determining the normal profit-earning capacity have to be devised. The interest on the amount of capital employed is then made the basis; and this principle having been introduced, any older-established firm can adopt it in preference to the actual profit earned in a pre-war period. In other cases, such as the mining industry, in which a wasting asset is involved, the dividends declared include a portion of the capital, since the exhaustion of the mine implies the disappearance of the capital. In such cases particular regulations have to be framed. The treatment of shipping is another vexed question, owing to the great fluctuations in capital, and demands especial consideration, rendered the more necessary by the high prices at which freightage is now being sold. The author, speaking as an expert, declares that the ascertainment of capital is the most difficult thing in the Acts, and the assertion is warranted. Fortunately, we have not to discuss here either the justice or the expediency of the methods devised by the Legislature, or we should have much to say. We have only to note how Mr. Snelling has acquitted himself in dealing with an intricate technical subject, and we believe his interpretation will meet with approval.

Finally, the Munition Acts come under consideration as the possible profits of "controlled" firms are strictly limited by special legislation, but the provisions of the Munition Acts differ from those of the Excess Profits Duty Acts both in structure and intent. The object of the Excess Profits Acts is to raise revenue, that of the Munition Acts to secure as large an output of munitions as possible. The Minister of Munitions is invested with powers in which accountancy and the provision of revenue have no part. Of the profits of a controlled establishment, all exceeding the "standard" of 20 per cent. is to be paid into the Exchequer, but the "standard," though based on the profit earned in two recent financial years, may be varied by agreement, or by authority of the Board of Referees appointed or designated by the Minister of Munitions for that purpose.

Personal.—The opening recently by Mr. Joynson Hicks, M.P., of the new premises of Messrs. W. G. C. Hayward and Co., Limited, at Cambridge Park, Twickenham, marks an interesting event in the history of aviation. The firm were one of the first—perhaps the first—of the smaller companies to realise the supreme need of an increased supply of aeroplane engines. Accordingly, they set themselves to specialise in this particular branch, and by careful work, on original lines, achieved considerable success. They were able to render conspicuous service to several of the large firms, who, in the unique conditions of the early days of the war, when shortage of engines necessitated a larger supply of spare parts for repair work, found difficulty in keeping pace with Government requirements, and who greatly appreciated the company's co-operation. The new works are equipped with modern machinery and particular care has been taken in their arrangement and construction to ensure both the comfort and efficiency of the workpeople.

Germany's Commercial Methods.—We read in the *Revue Générale de l'Electricité* that the French Government has learned from an authorised source that in various neutral countries, in Spain notably, the Germans are plotting the disorganisation of allied enterprises which compete with their own. They are offering very advantageous contracts to the greatest possible number of men belonging to the Allied enterprises, to lead these men to abandon abruptly their employment as soon as peace is declared. At the present time, the Germans are specially busy with the electrical undertakings, and they are endeavouring to bring about their stoppage by reason of a lack of experienced hands. German agents have carried out a complete investigation in regard to the whole *personnel* of the said Allied enterprises, from the labourers to the technical staff, to whom offers, to come into effect after the war, have been made, of situations much more advantageous than those they now hold. The contract insuring the situations is drawn up either in Germany or in Switzerland, and is signed before a notary public. Similar attempts at disorganisation are being proceeded with by the enemy in Switzerland.

PYROMETERS AND PYROMETRY.

(*Continued from page* 500.)

We continue our report on the Faraday Society's discussion of November 7.

High Temperature Control and Measurement.

The paper on "Automatic Control and Measurement of High Temperatures," by Mr. Richard P. Brown, was practically a description of the instruments of the Brown Instrument Company of Philadelphia. Nitrogen gas bulbs of copper, joined by capillary tubing to a helical expansive spring, were, it was stated, in favour in the United States for temperatures up to 425 deg. C., and cases in which the gauge was not more than 100 ft. from the furnace. The bulb capacity should be more than fifty times the capacity of the tubing and spring, to counteract the effects of atmospheric temperature fluctuations. Up to 1,100 deg. C. base-metal couples of nickel alloys (one wire 90Ni + 10Cr, the other 98Ni + 2Al) were used; for higher temperatures platinum alloys. The indicators of the firm were millivoltmeters of a resistance of more than 1,000 ohms, the high resistance being required to reduce or eliminate errors due to changes in the line and to general heating of the couple. The moving elements, pointer and spring, of such a pyrometer weighed only 526 milligrams, and consisted of an aluminium alloy covered with a very fine coating of enamel. The aluminium wire was drawn to a diameter of 0.003 in. (having two-thirds the weight of the formerly used copper wire), and the pointer tube had external and internal diameters of 0.012 in. and 0.008 in.; a further reduction in weight might be effected by using magnesium, but they had not yet succeeded in drawing magnesium for this purpose. The Brown heat meter, a modification of the just-mentioned instrument, gave a still higher precision. In this meter the dry cell e.m.f. of 1.5 volt was reduced by rheostats to 60 millivolts (or less), the maximum thermoforce of the thermocouples. In the first operation of the meter the couple was balanced against the dry cell; in the second operation the volts of the dry cell were determined, with the aid of a switch, by deflection; in the third operation the couple was joined to the meter, and by switching back and forth again quickly, either voltage could be measured; thus the line resistance with its fluctuations was eliminated. The last sources of error, sticking of the pointer, spring fatigue, &c., were guarded against by providing with the instrument a standard cell with a suitable resistance for checking the readings. The temperature of this cell, like all standard cells, should not vary outside the range 5 deg. to 40 deg. C.

The pointers of the millivolt meters were far too delicate directly to make contact in automatic control apparatus, but the object was obtained with the aid of a depressor arm—which is not novel, of course—driven by an electric motor or a clock. Below the pointer was a table carrying two contacts separated by a piece of insulating material, $\frac{1}{32}$ in. in thickness. With the help of these contacts a switch, a solenoid, and two rheostats in the electric furnace line, the temperature of a furnace which was to be kept at 1,400 deg. F., *e.g.*, could be so controlled that it would not sink below 1,300 deg. nor rise above 1,500 deg. By the aid of similar devices and a by-pass and automatic valve the gas or oil supply of furnaces was controlled. Mr. Brown finally referred to signal pyrometers. In multiple furnace installations three lamps with coloured glasses—red, white and green—were as a rule placed over each furnace to indicate too low, right or too high a temperature, these temperatures being controlled by a central pyrometer. For signalling, the thermocouples in each furnace were successively connected to the instrument through switches, and at the same time a switching mechanism connected the various sets of lamps at each furnace; the instruments were of the same type as those for automatic control.

Before opening the discussion on these first four papers, Sir Richard Glazebrook called upon Mr. S. H. Main, who, in the absence of Sir Robert Hadfield, explained the exhibits sent by Sir Robert, comprising the Brown millivoltmeter and the controller first mentioned, the latter regulating an electric furnace; further, a large chart, prepared by Sir Robert, resembling a thermometer, quite 10 ft. high, on which temperatures of interest to the metallurgist were marked, from − 273 deg. C. up to 5 + 5,000 deg. (solar heat), and also a chart due to Dr. Northrup indicating our knowledge and ignorance of facts at different temperatures; Dr. Harker's electric calibration furnace was also exhibited.

The discussion concerned in the first instance the Northrup induction furnace. Dr. H. S. Tailor, who had seen it in May, very much as now described, would hardly recommend the high-induction currents for everyday installations. Dr. Rosenhain also recognised both the difficulties, common to all electric furnaces, and the promising features of this furnace, about which further information was needed. Mr. E. H. Rayner pointed out that the 30-kw. outfit resembled that of a radiotelegraphic station for waves of 30 km. length. The nickel-carbon eutectic of Dr. Griffiths, Dr. Rosenhain said, was known to metallurgists and the iron-carbon eutectic might similarly be utilised for a fixed point near 1,130 deg. C. Portable workshop potentiometers were by no means impossible; Mr. Whipple subsequently added that Dr. Rosenhain himself had certainly devised a serviceable portable potentiometer. As regards the burried-cold junction, Dr. Rosenhain feared trouble from the heat and general conditions near a furnace, and also from subsidiary thermoforces at terminals. Mr. S. N. Brayshaw mentioned that he had found the eutectic alloy (60 Cu + 40 Sn)—the composition was stated by Mr. Whipple, who had supplied it—very useful for standardising pyrometers for workmen. The alloy was placed in a graphite crucible, covered with charcoal; the crucible was covered with sheet asbestos through the holes in which coal-gas was admitted and escaped; the burning gas melted the alloy, and for a quarter of an hour a steady temperature of 738 deg. C. could be relied upon before the fused alloy solidified. Mr. Paul and other speakers very properly regretted the deplorable use of the term pyrometer for different classes of instruments. Mr. Whipple, concluding the discussion, conceded that terminals should, of course, be avoided in accurate work; otherwise the compensating leads were useful. To close the opening plugs in furnaces by glass windows, as had been proposed, was inadvisable unless the absorption by the glass were known. He quite agreed with Mr. Rhodin, who had drawn attention to Wiborg's pyrometer for air blasts, and with other speakers that automatic control should more widely be adopted. It was quite possible to keep hot air blasts at 700 deg. C. constant within ± 10 deg.; soldering irons could be maintained constant within 3 deg. or 4 deg., and Mr. Horace Darwin had secured a constancy of 0.01 deg. for a prism-box.

The discussion of papers on metallurgical pyrometry, particularly of iron, which were next taken, made it clear that the problems involved are more complex than might appear, and that the readings obtained are not always properly interpreted, if properly understood at all.

Pyrometry in Steel Hardening.

Professor J. O. Arnold, F.R.S., opened this series by giving some, so far unpublished, notes on "Pyrometry Applied to the Hardening of High-Speed Steel," and also on the temperature of tapped steel. High-speed steel, he remarked, was a ticklish subject. But it was generally agreed now that such steel was best hardened from a temperature of 1,300 deg. (always deg. C.) produced in a bath of barium chloride fused by the aid of iron electrodes. They had at Sheffield University taken simultaneous observations with five instruments: a Féry radiation pyrometer, a Féry spiral spring pyrometer, a Foster practical immersed pyrometer (containing a thermocouple of michrome and some other nickel alloy for a range from 500 deg. to 1,400 deg., the twisted end of the couple being immersed), a Leskole pyrometer (a modified Wanner which Professor Arnold did not prefer to the Wanner), and a Mesuré-Nouel (also a polarisation pyrometer for which he had a certain affection, though it embodied a large personal equation). All these instruments were reliable only for temperatures above 900 deg. C. With trained observers (senior students) they had obtained results in splendid agreement, however, probably because they had black-body conditions; many discrepancies were due to want of skill of the observers. The mean of the bath observations was 1,296 deg. a few extremes ranging from 1,270 deg. to 1,310 deg. Another set of observations, with three instruments, had given the grand mean 1,305 deg. Passing to steel temperatures, Professor Arnold stated that, when first using their 2-ton Siemens electric furnace in 1910, they had charged it with ½ ton of pig-melt of hematite iron, cooled the metal a little in the ladle for casting floor plates, and taken the casting temperature of the five consecutive plates, which yielded 1,300 deg., 1,280 deg., 1,243 deg., 1,258 deg. and 1,208 deg.; there had thus been a pretty rapid fall (radiation loss) of temperature, the mean fall being 18 deg. per plate. In 1914 Leskole and Mesuré instruments had given a suspiciously high casting temperature of 1,525 deg. Later experiments had yielded first-heat tapping temperatures of 1,600 deg., 1,550 deg., 1,630 deg., 1,670 deg. and 1,620 deg., and in another series 1,625 deg., 1,600 deg., 1,600 deg., 1,600 deg., 1,590 deg. and 1,600 deg.; that last run of the figure, 1,600 deg, looked almost too good. During the discussion Professor Arnold afterwards remarked that two solid points had been proved: The temperature inside the Siemens' furnace was 1,700 deg. to 1,750 deg., the tapping temperature of the molten metal 1,575 deg. to 1,525 deg.

Temperature of Liquid Steel.

In his paper on "The Determination of the Temperature of Liquid Steel under Industrial Conditions," Mr. Cosmo Johns, F.G.S., M.I.Mech.E. of Sheffield, pointed out that there was a marked thermal effect when liquid steel issuing from the tap hole of an acid open-hearth was succeeded by the first flush of slag. Viewed through blue glass the slag was much brighter than the steel. The steel would reflect the light of the sun or an arc lamp, while the slag was less efficient as a reflector; as good reflectors were poor radiators, the differences in emissivity had to be taken into consideration. The thermal effects would be studied with a Féry radiation pyrometer, but marked corrections had to be made when different parts of the stream of metal were in the field. Optical pyrometers for monochromatic light had proved most useful, provided special precautions were observed; that experience agreed with the experience of Dr. Burgess in American steel works. The liquid steel was best observed from a distance of about 12 ft. at nearly a constant angle, and to avoid fumes, from the clear side to the windward of the stream. Experienced observers could estimate temperature differences of 15 deg. and even 10 deg. C. merely by watching the steel through blue glass as it was poured into the ladle. Pyrometers should be able to give higher accuracy, and trained observers could indeed obtain readings agreeing within ± 2.5 deg. or ± 5 deg. at any rate. For each particular casting method of a class of steel it was only necessary to determine the "normal" temperature when the steel was tapped from the furnace; deviations from the normal by more than ± 10 deg. were avoidable in practice, at least for special steels.

As regards the temperature distribution in the furnace hearth, there was a layer of, say, 4 in. of liquid slag between the flame and the liquid steel, 15 in. deep, and all the heat had to pass through that layer which was therefore hotter. In correcting the apparent temperature readings, assumptions had to be made for the emissivities. The surface layer of slag consisted of fused iron peroxide, which Mr. Johns supposed to have an emissivity of 0.50; the emissivity of the liquid steel was probably 0.40. Insertion of a patch of new silica brick in a seasoned wall might make a difference of 20 deg. Observations (detailed lower down) indicated that there was a temperature gradient in the liquid steel bath, which could be estimated by observing the stream, first of steel and then of slag, as it flowed from the taphole into the launder. Nine consecutive determinations taken at intervals of one minute had given the

following degrees Centigrade; clear steel, 1465, 1470, 1470, 1475, 1475; last steel, 1480; clear slag, 1495, 1505; last slag, 1510. There was thus a rise of 15 deg. in the first 5 minutes, and a sharper rise in 2 minutes as the slag appeared. When the temperatures were determined at the top, middle and bottom of a stream of steel and slag, the top of the steel was by about 15 deg. colder than the bottom, except when the metal was deoxidised in the ladle, in which case the top was hotter by 5 deg. or 10 deg.; the bottom of the slag was always hotter than the top by about 5 deg., All these temperatures were remarkably concordant in many determinations, but uncorrected. Assuming an emissivity of 0.50 for the steel and making measurements with red light of $\lambda = 0.70\ \mu$, Mr. Johns found the following apparent (and corrected) temperatures in degrees Centigrade: Centre of hearth, 1600 (1704), centre of roof 1585 (1607), tapping side wall 1625 (1732), port block where gas last entered 1645 (1755), exit port block 1635 (1743), surface of bath before tapping 1625 (1754). As regards thermal losses there was a sharp drop in the readings when the clean surface of the steel in the ladle was compared with the stream flowing from the tap hole; but once the steel had been covered by its protecting layer of slag, after five minutes, the thermal losses rapidly diminished. Concluding, Mr. Johns emphasised the need of trained observers, who should be able to take apparent temperatures with optical pyrometers at $\lambda = 0.65\ \mu$, correct within $\pm$ 5 deg.; plane surfaces or curved surfaces of large (not small) radius should be viewed. All moving surfaces were, however, either rising and falling in temperature, and the relative time of the observations was thus an important factor. That workmen could so well control a furnace temperature was partly accounted for by the fact that the open-hearth, fed with producer gas of regular composition, was of a constant temperature, hotter than the walls, and acted itself as a pyrometer. In some points Mr. Johns differed from the observations made by Burgess in American steel works; the fault was probably due to the glass which Burgess had used. The demands made by Mr. Johns are very high, considering that we are not certain of high gas thermometer readings within several degrees, and the reader will recognise that general statements as to metallurgical temperatures without particulars as to method and conditions are of little value.

Temperature Determinations of Liquid Steel.

Dr. McCance, of the Parkhead Steel Works of Messrs. W. Beardmore and Co., Glasgow, followed with an important communication on "Temperature Determination of Liquid Steel," and on experiments which he had conducted, he stated, since 1913, in conjunction with Mr. Service in the works mentioned for the purpose of controlling the temperature in an open-hearth furnace by the aid of an optical pyrometer. They had had difficulties in evolving the system now in use by which from 10,000 to 12,000 determinations were made in a year. With the Siemens optical pyrometer used—in which a carbon filament was heated by the current until its colour was that of the object on which the pyrometer was focused—it was difficult to keep the milliampere meter constant, and this therefore required frequent standardising. The pre-war certificate supplied with the instrument gave the currents necessary for different temperatures; these temperatures were about 20 deg. higher than those of the National Physical Laboratory standard tests against a black body. The wave-length of the light used and every other detail should be standardised in all optical instruments. Testing a heated object by means of a thermocouple and the optical pyrometer with different screens he had observed the following great differences: thermocouple, 1188 deg. C.; Siemens optical, 1186; using three Wratten screens: L 1133, Hg 920, blue 750 deg. C. The Siemens instrument was supposed to work with $\lambda = 0.65\ \mu$, but he had not measured the wave-length. In other recent tests of three new instruments, all supplied with certificates "correct," readings on the same opening (black-body conditions) had given in the three cases the values: correct, 15 deg. low, and 20 deg. low, the comparison standard being a thermocouple. As regards the temperature inside an open hearth the apparent temperature recorded by the optical pyrometer would be the true temperature *plus* an amount which would depend upon the temperature of the flame, the uniformity of the furnace walls, and the reflective emissivity of the slag surface, all insufficiently known. As it was not advisable to shut off the furnace every time a determination was taken, it was decided after experiments that the best places to focus the instrument on were the slag surface opposite the part that the gas was entering and the furnace roof immediately above it. At first widely varying temperatures, 1,500 deg. to 1,700 deg. and over, were recorded. The furnace man was controlling the temperature by his eye, which, for the experienced melter, meant not only by the colour, but also by the condition of the brickwork, the fluidity of the slag, the appearance of surface bubbles, and other "infallible" secrets of the art. Towards the end of the operation, when the slag was thickening up, seemed to be the time when there was the greatest tendency to put more heat into the furnace than the brickwork could stand. Ultimately it was found that the temperature could, by means of temperature observations, be kept between fairly close limits running from about 1,630 deg. to 1,650 deg. C. apparent temperature, with advantage to the life of the furnaces.

When the metal was running out of the furnace, the observer should stand to the windward of the stream to avoid smoke; the diameter of the stream was also of influence, but that was generally within the limits of experimental error, as were also the differences in different parts of the stream mentioned by Mr. Johns. For practical purposes an accuracy of $\pm$ 5 deg. was all that was required, and that could be obtained with instruments properly looked after in the hands of men experienced in taking temperatures under shop conditions. The presence of carbon, manganese and chromium altered the apparent temperature of the steel, probably by altering the emissivity. An average apparent temperature of liquid steel was 1,500 deg. which, accepting Burgess' doubtful value for the emissivity of iron 0.40, gave a true temperature of about 1,600 deg. C.; casting temperatures below that figure Dr. McCance considered as cold heats. Although taking the furnace temperature seemed to ensure that all casts would have the same degree of heat, the problem was not so simple; other factors entered, of greater importance even than surface temperature. There was the amount of heat carried forward in the bottom of the hearth by the previous charge; the temperature of the bottom just before putting the charge in was no indication, as the surface was easily chilled by cold air from the door. The rate at which the charge had been melted down, and the rate at which the bath boiled up also determined the heat put into the charge, and these problems had not yet been solved quantitatively. Dr. McCance also deprecated taking readings of flat surfaces of steel, as they were always covered with slag or oxide which had a higher emissivity than the clean steel surface, and gave too high readings; therefore the instrument should be focused on a moving part of the stream of metal.

(To be continued.)

INDUSTRIAL NOTES.

A deputation from the Federation of General Workers, including Mr. J. N. Bell, J.P. (president), and Mr. J. O'Grady, J.P., M.P. (secretary), presented to the Ministry of Munitions on Saturday, November 10, the claim of the general workers in the engineering and foundry trades for an advance of 12½ per cent. in wages. The following announcement was issued after the meeting:—

"The matter of the claim of general workers in engineering and foundry trades for an advance of 12½ per cent. in wages is under consideration by a representative committee of the trade unions concerned, and the Ministry of Munitions, together with other Government departments interested, with a view of placing the whole question before the War Cabinet for their early decision.

"In these circumstances the representative committee of the trade unions appeal to their members to remain at work pending the decision of the War Cabinet."

The representative committee of the trade unions affiliated to the National Federation of General Workers, who are negotiating with the Ministry of Munitions for the extension to their members employed on time rates in the engineering and foundry trades of the 12½ per cent. recently granted to skilled time workers, met the representatives of the Ministry of Munitions on November 12. A complete statement giving the claim and the classes of workmen affected, together with the approximate numbers and cost was submitted. The department undertook to present the claim to the Minister for submission to the War Cabinet.

In view of the difficulty in meeting the demands for various materials and labour required for the maintenance and renewal of the permanent way and rolling-stock of the tramway undertakings, the Board of Trade are appointing a committee to consider the needs of these undertakings, so that the necessary steps may be taken to supply, as far as possible, such needs, even though it may be at some temporary sacrifice to less essential undertakings. The Municipal Tramways Association and the Tramways and Light Railways Association are being invited to nominate members to the committee, and the board have asked the London County Council to allow Mr. A. L. C. Fell, the manager of their tramways, to serve on it. Mr. James Devonshire has been invited to be chairman of the committee. It is not intended that the control of tramway undertakings should be interfered with by the committee.

The Minister of Munitions has found it necessary to reconstitute the Special Arbitration Tribunal on Women's Wages in view of the increasing volume and importance of the work transacted by that body. All differences as to rates of wages, hours of labour, or conditions of employment of women and girls, engaged on munitions work are referable to the tribunal, and the tribunal also acts in an advisory capacity when referred to by the Minister for advice as to what directions he shall give on the matters in respect of which it conducts arbitration.

The Hon. Alexander Shaw, M.P., has accepted the Minister's invitation to become chairman of the tribunal. Mr. Shaw has also accepted the chairmanship of the Skilled Men's Wages Tribunal.

In the course of a letter to *The Times*, Sir Algernon F. Firth, president of the Association of Chambers of Commerce of the United Kingdom, says that profits have arisen mainly from two causes: The rise in the price of all raw materials, and the amount of repetition work done, coupled with continuous employment. Sir Algernon then states: "The difficulty which we foresee, and which is causing the greatest anxiety in the minds of most manufacturers, is how they are to find the working capital that will be necessary to enable them after the war to resume their pre-war sphere of operations and even to extend these for the advantage of the many who will be requiring employment. The working capital, i.e., the sums required for stocks of raw materials and goods, and also for credits to customers, for the same turn-out as before the war will, so long as present values hold—and I have no doubt they will for a considerable time—be at least double after the war. The problem is where this working capital is to come from. There will be enormous demands upon the banks, and it is doubtful if they will have funds sufficient for the purpose. It will not be temporary loans that will be required, but loans probably for some years until values fall. Our banking system does not lend itself to providing funds upon such a basis. Business men in the United States and Germany, we know, have accumulated large sums for after-the-war trade. It would be impossible for a British manufacturer to compete with them if his working capital is taken either in the form of excess profit or of conscription of wealth. If the State takes the capital now, it will have to provide other capital later on, or our industries will be compelled to limit their operations, and the business and employment will go to the foreigner.

"I think," concludes Sir Algernon, "this position should be realised by all who are discussing this subject, and I trust that nothing may be decided upon that will jeopardise the continuance and expansion of our industries."

Sir Hugh Bell delivered an address at Huddersfield on Saturday, the 10th inst., on "The Rights and Responsibilities of Capital to Industry." Sir Hugh defined capital as the result of skill and abstinence applied to production, and said it seemed difficult to deny to its producers the right to dispose of it at their good pleasure. Capital was an advantage to the community, since it permitted the provision of the means of existence independently of the fluctuating conditions of the weather, and of society. Were it not for accumulated wealth a deficient harvest meant

starvation. It, further, enabled a nation to withstand the attacks of other nations who sought to plunder it. But if the community as a whole was benefited by the act of those who accumulated capital, was it wise, he asked, to deter men from continuing to accumulate? Again and again one heard claims that the State should assume the ownership of this or that species of property. It seemed to him that all such claims, whether large or small, rested on fantastic and insecure foundations. They assumed, in the first place, the existence of an all-wise and omniscient entity called the State. Who should judge the value which should be put on various sorts of services, and what assurance had they that certain services would, in fact, be rendered if those who were able to render them failed to receive the reward to which they regarded themselves as entitled? He set very high the right of the community as a whole to the exercise by each member of the whole of his powers. It might be said to be a question of degree, and so perhaps it was, but there remained to each the right to refuse and to take the consequences. That right he was not prepared to surrender. Its existence constituted the check which made the community hesitate to exercise that ultimate and tyrannous power with which it was hypothetically endowed. All the more necessary was it for those to whom the democratic solution of social problems appeared to be the only one possible, to guard with sedulous and unremitting care that freedom which might stand more in jeopardy from the mob than from the monarch.

In regard to the responsibilities of capital, Sir Hugh said he believed a great deal of the existing unrest would be allayed if the class in which it prevailed were taken more fully into the confidence of the capitalist. As a result of many years' study, he was convinced that of the gross income derived from industry, by many times the greater part went to the men actually engaged as labourers, whether skilled or unskilled. He challenged any one with knowledge of the subject to contradict the statement that in most businesses an advance of wages amounting to 10 per cent. would have left nothing for the owners of the works. A grave responsibility rested upon the capitalist whose wealth was invested in industry to make this clear to the men. Sir Hugh added that he wanted no wage slavery. He was not wedded to an eight-hours' day. He desired men to have reasonable leisure to enjoy the fruits of their labour. But he wanted men, in return for their wages, to do an honest and strenuous week's work, and to bear in mind that the only source from which their wages could come was the sale of the commodity they produced. The ill was easy to state, the remedy more hard to find. Of one thing he was sure, it did not lie in the intervention of the State—still less in help from the public purse. Those who were engaged in industry had to find the remedy themselves, and in order to succeed in that, they had to consider the problem with willing and open minds.

In the course of an interesting address by the president, Mr. J. E. Fletcher, M.Inst.M.E., delivered last Saturday before the Staffordshire Iron and Steel Institute, the speaker stated that Sir William Ashley and Sir Robert Hadfield, whose help in fixing the attention of our manufacturers on the economic problems facing the nation was so necessary and timely, had recently directed our thoughts to the necessity for a closer study of manufacturing economics, and had, unconsciously perhaps, brought into closer touch the Chambers of Commerce and the scientific institutions.

In the works, added Mr. Fletcher, there was a more intimate touch needed between the works cost accountant and the practical works man. The American term "cost engineer" was suggestive of the practical use the United States had made of the study of manufacturing economics. The exigencies of the times had brought into Great Britain an atmosphere charged with "regardless-of cost" ideas, and one of the things the metal-producing world had to face ere long was the elimination of the spirit of extravagance, and a very difficult task it would prove to be. Neither excessive wages nor abnormally high profits could be permanently or economically sound, and the desire on the part of masters or men for such temporary artificiality could not long be satisfied without disaster to the industry and to the State. If, as was strongly evident, the use of complicated labour-saving devices must become common in the future, the necessity for giving the worker an interest in keeping up the efficiency of the tools will become imperative, for nothing was so wasteful as a badly operated semi-automatic machine, or a so-called "automatic" tool when in poor order.

The Ministry of Munitions, in a letter dated the 12th inst., addressed to the secretary of the London Association of Foremen Engineers, states the following:

"I have to refer to the interview with you on November 9 and previous interviews with regard to the remuneration to foremen in controlled establishments.

"In reply, I have to state that the Minister has no power, under the Munitions of War Acts, 1915 to 1917, to make any award applicable to persons in receipt of an upstanding salary, and it is contemplated that, in the first instance, employees should negotiate with their employers in the ordinary way and endeavour to arrive at an agreement, which should then be submitted to the Minister for consideration. In the event of deadlock or failure, it is open to either party to refer the matter to the Ministry of Labour (Chief Industrial Commissioner's Department).

"With regard to the 12½ per cent. bonus which has been awarded to time workers under the Skilled Time Workers' (Engineers' and Moulders') Wages Order, 1917, I have to state that this department would be prepared to consider an advance to the foremen and draughtsmen in receipt of emoluments not exceeding 250*l.* per annum, provided that they are not in receipt of a bonus on output, and proposals which have been agreed between employers and employees with regard to this should be similarly submitted to the Minister for his consideration."

With further reference to our statements on page 489 *ante* in regard to the military "comb-out" in the South Wales collieries, the latest official figures of the vote show—

For the "comb-out"	....	....		96,733
Against	....	....	....	26,700

or a majority for the "comb-out" of 70,033.

The membership of the South Wales Federation is stated to be 160,000, but the workers under 16 years of age were not allowed to take part in the ballot. It is estimated that 40,000 men had, during the war, gone into the South Wales collieries from other industries, and these men are affected by the vote, since the Blackpool Conference decided that they should first be "combed-out" of the pits before other men were taken.

The exemption certificates which were given to all men of military age who entered the mines from other trades since August 4, 1914, are to be withdrawn.

The attention of employers and of social and benevolent organisations in contact with the Navy and the Army is called to the fact that without the express permission of the Army Council, no alien may be engaged on any form of auxiliary war service. This safeguard, already adopted in the case of alien munition workers, was extended on October 15 to all aliens seeking employment connected with naval, military and aeronautical work, with telegraphs, telephones and railways, with naval and military and civil hospitals, and with social, benevolent and religious organisations for the benefit of, or, in contact with His Majesty's forces. Before an alien may be engaged for any of these auxiliary war services, he must have his identity book specially endorsed with the permission of the Army Council. Aliens already employed prior to October 15 must also comply with this condition.

Employers are therefore required to see that both present and prospective alien workers of this description are approved by the Army Council.

Identity books (together with passports or provisional certificates of nationality) should be forwarded without delay to "The Secretary, War Office (M.I.5.A.), Whitehall, London .S.W.1," in order that the necessary endorsement may be given if the service of the alien is approved.

Notice of the termination of the engagement of any alien so employed must be sent to the nearest Employment Exchange as well as to the War Office (M.I.5.A.).

The Committee on Production issued last Tuesday, the 13th inst., its award in regard to a difference which had arisen between the Welsh Plate and Sheet Manufacturers' Association and the British Steel Smelters, Mill, Iron, Tinplate and Kindred Trades Association, the Tin and Sheet Millmen's Association, the Dock, Wharf, Riverside and General Workers' Union, the National Union of General Workers, the Welsh Artisans' United Association, and the Amalgamated Society of Engineers, representing the other unions and associations concerned.

The award is that the present scale of percentage bonus shall continue and that, in addition, the men concerned are to receive an advance of 5*s.* per full ordinary week as from and including October 22, and from the same date the boys, youths, and apprentices under 18 years of age, an advance of 2*s.* 6*d.* per full ordinary week. Boys, youths and apprentices, on attaining the age of 18, will receive a further advance of 2*s.* 6*d.*

The Committee has made a similar award in respect of an application by the Iron and Steel Trades' Confederation on behalf of their members in the employ of members of the South Wales Siemens Steel Association.

WORM GEARING.

To the Editor of Engineering.

Sir,—I am sorry to note that Mr. Walter C. M. Pettingill in his letter to you on the above subject has not appreciated the rolling action which I endeavoured to explain as taking place between the worm and the wheel teeth when uniform velocity obtains.

I have no fault to find with his definition of the "velocity of rubbing," but in his application of his definition he has overlooked the velocity of the point of contact, which is quite different to the actual velocity of either the worm or the wheel teeth, and in obtaining the real rubbing velocity between these teeth, cognizance must be made of the velocity of the point of contact, together, of course, with its direction.

A similar analogy takes place with the tooth action of ordinary spur gears. Their pitch-line velocities are equal, but on account of the point of contact travelling along the line of action at a certain velocity, a rubbing velocity is set up between the teeth, which, according to the argument of your correspondent, does not exist. The essential point to bear in mind is that contact between these gears takes the form of a combination of rolling and sliding action, the former having the effect of reducing the theoretical rubbing velocity.

Yours faithfully,

Francis J. Bostock.

Park Works, Lockwood, Huddersfield,
November 14, 1917.

PROFESSIONAL MEN AND GOVERNMENT EMPLOYMENT.

To the Editor of Engineering.

Sir,—May I, through the columns of Engineering, draw attention to the very unfair embargo which is placed upon the services of professional men engaged in Government offices. Anyone who desires to improve his position finds this clause inserted in almost every advertisement, Government or otherwise, where professional services are required, "No one on Government work need apply." I, with many others, who early in the war took up Government work when their services were wanted, now find their way to advancement practically barred by the above clause.

I think we are all sufficiently patriotic not to wish to hamper the Government in any way, but patriotism won't pay bills, neither will pre-war salaries which, with few exceptions, are now the rule. No class of men have been harder hit, through the war, than the professional class, and the Government might give thought to this question of remuneration and so relieve to some extent the many anxieties which now oppress the above class or let them have a free market for their services. When positions of more responsibility are required to be filled by the Government could they not seek amongst their own servants for suitable candidates and not go outside.

This would be some encouragement. But now no matter what a man's experiences may have been, nor how much he may feel that he could put his services to better use, he is tied down by an objectionable clause and without compensation.

Thanking you for giving me the privilege of your columns, I enclose my card, and beg to remain

Yours truly,

November 13, 1917. "Technical."

DRAUGHTSMEN.

To the Editor of Engineering.

Sir,—Being a draughtsman and a member of the A.S.E., I have been much interested in the correspondence appearing in your columns. I note it is the object of one or two seniors to form the Association of Engineering and Shipbuilding Draughtsmen into a trades union. Then to make working arrangements with other trades unions to get their voices heard. I would like to point out to your readers that the working arrangement already exists. The A.S.E. is open and has been open to draughtsmen ever since it was established in 1851. My advice is therefore for all draughtsmen to join hands with their workmates in the shops by being loyal to the union which has helped them in the past, and become members of the A.S.E.

Yours faithfully,

"Senior A.S.E."

To the Editor of Engineering.

Sir,—The discussion in your columns is of great value at the present juncture, as it will promote that thorough consideration which is essential to a sound definition of the association's policy. Mr. Frederick H. Auger, after criticising the brevity with which "Senior Draughtsman" had put forward his suggestion for a formal alliance with "Labour," suggests, with no more introduction than "I think it must be admitted," that "our policy of splendid isolation" is the most satisfactory.

It is on this point that I wish to join issue with him. Isolation is sometimes sordid, often just miserable, in other cases the mere expression of vanity, but in no circumstances can it be splendid. It is exactly the attitude of the few draughtsmen who remain outside the association on the ground that they can do quite as well for themselves as the association can for them.

It may be that the association would be very successful in the isolated position approved by your correspondent, just as those outside our body may do themselves very well as individual draughtsmen. But the relative value of the courses open to us must always remain a matter of speculation because we can only take one of them.

It is very much like getting married; whether you do it or whether you abstain certain results follow; but

what would have happened in the contrary case cannot even be guessed at. But this much is fairly certain; in spite of our "unique position" (this sounds very well but can anybody say exactly what it means) our position must depend mainly on the general social and economic conditions obtaining, and *after that* on the adjustments made as a result of our own individual and collective efforts. Even lawyers and doctors cannot do any better if you think it over carefully.

So, even in our own interests, it is necessary for us to get off the pedestal on which we have been inclined to plant ourselves, and come down into the hurly-burly of the social struggle. But there is more in it than that; just as a man who lives an entirely self-centred life is usually of much less account than one with broad interests, so, in like manner, an association that lives entirely to itself, that will espouse no cause but that from which it is likely to get either gain or credit, is very likely in the end to be of little use to anybody.

Mr. Auger thinks that our position should be analogous to that of the Law Society or British Medical Association: here, again, a little elucidation is required, but it is worthy of remark that "splendid isolation" has never been the policy of these in any matter affecting their interests.

In particular, the position of lawyers is a direct result of a strict attention to politics.

In conclusion, I should like to endorse Mr. Auger's request for the very fullest consideration of all proposals before any decision is taken. After all, it is something to be proud of that such a large percentage of draughtsmen have joined our association in so short a time, and the potentialities are such that it would be a pity if we did not make sure that the course adopted commanded not only a majority, but very general consent.

I am, Dear Sir, yours truly,
R. J. Lappin.

"Argonaut," Bramber-road, London, N.12,
November 12, 1917.

To the Editor of Engineering.

Sir,—My letter seems to have caused somewhat of a flutter among the members of the Association of Engineering and Shipbuilding Draughtsmen, and the one written by Mr. F. H. Auger invites a reply. Both of us are members of the above organisation, and, I presume have the desire to see it flourish, gain strength and become a power for good, for our profession. I join with him that careful consideration must be given by every member of our association with regard to registration, hence my reason in writing explaining my views, which I know are shared by many others.

To suggest that the contention that those who favour a trade union do so with the one idea of fostering and creating industrial strife is unfair, and not playing the game, and I trust that any future criticism will not descend to the gutter. The power to strike has nothing whatever to do with registration, and it is illegal for any body of men to declare a strike during the operation of the Munitions of War Act.

Registration is not purely a question of the allocation of funds, and I think my friend is mixing up the Trade Union Act with the Friendly Societies Act. For what reason has our association been formed, except to protect ourselves against the Masters' Federation? We are forced to act on similar lines to those of the trade unions, but are not one of the latter; and it is far preferable to act openly and lay our cards on the table. We are not recognised by the Masters' Federation, and naturally they will take advantage of any weakness in our constitution.

Registration is simply a safeguard; it gives us a legal standing, facilitates banking transactions, and there are many other points that I could mention but think my letter will plainly show to our members that registration as a trade union is absolutely necessary. As far as I know there are three methods of registration open to us, viz.: (1) Provident society; (2) educational society; (3) trade union. The first means being based upon an actuarial basis, a long and costly business; the second, to my mind, would give a wrong impression of what the association was created for, and would not foster that bond of fellowship which is necessary to our profession. The third and last, in my opinion, is the only practical solution if we intend to elevate the status of our profession, and I would remind my friend that this can only be done by obtaining the necessary increases in salary. The three large and powerful masters' federations have allied themselves together, and, seeing that we are merely workmen, my reason is obvious for suggesting we should become allied with Labour and sink class distinctions.

Until we are registered as a trade union we cannot become members of the Engineering and Shipbuilding Trades Federation, commonly known as the Allied Trades, and the moral and practical support which such a body could give to us will in future days be necessary.

Although I regard the weapon of striking as a barbarous method of settling disputes, I have not sufficient effrontery to assert that strikes are only resorted to by weak organisations. Such a statement shows a lack of knowledge, a biased opinion, is entirely false and without foundation. I look forward with hope to the day when differences of opinion between employer and employed will be settled by the saner means of arbitration. It needs a bold man to make the assertion that our association has been able to press successfully the demands of our profession, and until we drop the idea of that splendid spirit of isolation we shall still find ourselves in the same boat; and, in the days that are to come, it will begin to sink.

The question of the granting of war bonuses will blow my friend's arguments into thin air. The allied trades have secured for its members by peaceful means since the beginning of the war, increases amounting to 20s. per week plus 12½ per cent. bonus, and I defy your correspondent to show that draughtsmen have secured such favourable terms on a national basis. Take, for instance, the fitter in the Manchester district, who is in receipt of wages of 59s. per week plus 12½ per cent. on total earnings, and payment of overtime, while the average wage of the draughtsmen, including war bonus, is about 58s. per week, and no overtime.

I agree with our friend, the draughtsman does hold a unique place in industry, for he supplies high technical and practical skill in return for low wages. It is no use referring to the much-vaunted British Medical Association. They are their own employers, whilst we are employed. But even that body has found it necessary to register as a trade union.

The employers of to-day praise the skill and loyalty of their staff, until they ask for advances. I heard of one body of draughtsmen in the Manchester district, on making application for the 12½ per cent. increase for skilled engineering draughtsmen, being told they were not skilled workers, and the order applied to the marker's-off in the shop.

I would again remind our members to bring forward this question at their annual meetings so that our association may be built upon the rock and not upon a foundation of sand.

I remain,
"Senior Draughtsman."

To the Editor of Engineering.

Sir,—The present discussion on the position of draughtsmen, to which you have so generously opened your columns, should be full of interest both to the employer and to his technical drawing-office staff.

It is perplexing, however, to find the almost diametrically opposite views which are being expressed in the correspondence—*e.g.*, Mr. Auger's letter on the one hand, and "Senior Draughtsman," for example, on the other. Might I suggest to the former that his attitude on the subject of trade union registration is based on a very superficial study of what this means? He seems to consider that registration will somehow convert the association in spite of itself into "collecting-box and strike banner" organisation, and I am afraid that a number of others, after equally cursory examination of the question, think similarly.

As the association is at present constituted, there is no protection to its funds from legal action following on even mild recommendation as to procedure on the part of draughtsmen with genuine grievances. Such recommendation need not (and would not, I hope) be anything directed towards open strike. It might take the form of advice not to engage with certain firms if possible, to leave such firm's employ to better conditions known to be got elsewhere, not to work excessive and underpaid overtime, and numerous other points which a trained legal mind would easily discover by which to attack the body as being guilty of "restraint of trade." Nor is there at present any safeguard against defalcations by its own members and officials. These two points are entirely covered by registration under the Trade Union Act. In support of the contention that mere registration does not willy-nilly make an association an aggressive one it may be pointed out to those who have not had opportunity of inquiry, that there are many bodies so registered, which it is preposterous to imagine are objectionably aggressive—these including certain employers' federations!

The "policy of splendid isolation" referred to by Mr. Auger would not be interfered with necessarily, as the association would not be bound always to act along with any other trade union, although on occasion this might be advisable. Our self-improvement side, by technical discussions, publications, &c., would not suffer in any way as far as I can see. Then, again, it is daily becoming more evident that reasonable war bonus advances, especially to those draughtsmen employed by small firms, could have been by this time much more easily obtained, had the association been registered and appearing, either along with the shop trade unions, or on its own behalf, before the Committee on Production to explain the deplorable condition of draughtsmen since the war.

The situation which may arise following the Whitley report, by which Local and National Industrial Councils to promote better relationships between Capital and Labour are to be formed, has also to be considered. None but trade union representatives will be allowed on these councils, and surely it is desirable that draughtsmen should be members of such bodies?

When Mr. Auger says that "not all trade unions are registered" to avail "themselves of this protection," he is again in error. Those that are unregistered, come, nevertheless, very often under the protection of the Trade Union Act, by means of a special application provided for under this Act, and only differ in this minor respect. Your correspondent also talks of the association being able successfully to press its demands without resort to such means. Has it not occurred to him that it is chiefly because the engineering industry is at present Government controlled, that an irregular body like ours has been able to do anything at all? And that after the war it will possibly, in spite of its large and enthusiastic membership, be in much the same impotent position that it occupied before the war, through inability to move in any direction without the danger of being stripped bare?

Another remark of his calls for comment. He states that it is fortunate that the original constitution of this body was sufficiently comprehensive and vague not to frighten off people with "cherished personal opinions." No doubt a great many draughtsmen, with objections to trade unionism generally, would have been reluctant to join a body with views on registration, though not necessarily, as shown above, with desires for aggressive action. Is it so certain that those same people, who have recently seen the relatively good treatment of the trade unionist, and who might become enlightened in regard to their prejudices—is it so certain, I repeat, that they would be similarly reluctant now?

We are all at present, no doubt, called upon to make certain sacrifices, and claims to raise wages to the level of their pre-war value are probably therefore unsound. But why should the skilled draughtsmen, who were, some of us contend, already underpaid before the war, be called upon to make a greater relative sacrifice than any other skilled worker?

It has always appeared astonishing to me that employers generally, with few exceptions, have made no attempt, indeed have resisted attempts, to bring the draughtsmen, the brains of their business, up to a position to which the term abnormal sacrifice could not so easily be applied as it can to-day. Surely a discontented brainworker loses more of his efficiency relatively than any manual worker? And it looks, therefore, as if employers pay little regard to efficiency as long as profits are all right through abnormal war conditions.

It may be as well to point out to "Draughtsman" (letter in November 9 issue) that, unfortunately for us, the Ministry of Munitions can make no order to pay the 12½ per cent. skilled workers bonus to any but time workers (Munitions of War Act, 1917), a "recommendation" to employers that they ask permission to pay it from the Minister being all that can be hoped for meantime. It is a question of altering the Act of Parliament so as to permit "orders" of the kind being applied to staff men, and it is to be hoped that the Minister, who it is reported is drafting a new Bill, will amend it accordingly.

Yours faithfully,
"Accelerando."

DRAUGHTSMEN IN GOVERNMENT DEPARTMENTS.

To the Editor of Engineering.

Sir,—The publication in your columns recently, and in the press generally, of an undertaking given by the Ministry of Munitions to the Association of Engineering and Shipbuilding Draughtsmen that a 12½ per cent. increase, under the "time workers" award, would be given to all draughtsmen, came as a very welcome announcement. Whether this pledge is to embrace draughtsmen other than those in Government Departments, only those who received it can best judge, but up to date the Ministry of Munitions has shown no disposition to extend it to draughtsmen in their own department. As a very large number of draughtsmen attached to Government departments are members of the aforementioned association, it will be interesting to see to what extent it can secure the fulfilment of this promise.

As one who can speak for hundreds of these draughtsmen on "time rates," I can assure you that though they were much earlier in the field than the Association of Engineering and Shipbuilding Draughtsmen with their claim, nothing has been done in this direction, nor is there the slightest evidence of the Ministry of Munitions' intention to move in the matter. On the contrary, there is a determined attempt to resist the inclusion of draughtsmen in Government departments.

The traditional parental *rôle* of the Government was never more falsified than in the present instance. While the desperate struggle rages for the preservation of the liberties of nations abroad, especially the lesser ones, and to combat the pernicious principle that "might is right," every opportunity is sought to checkmate smaller bodies of employees at home. In this matter, the Government, and particularly the Ministry of Munitions, have outprussianed the Prussians, and it behoves all draughtsmen in their employ to join forces both for their present and future security.

Yours faithlfully,
November 12, 1917. "Dessinateur."

British Standard Specification for Charging Plug and Socket.—We have received from the Engineering Standards Committee a copy of the revised British Standard Specification for Charging Plug and Socket for Vehicles propelled by Electric Secondary Batteries (Report No. 74–1917). The great importance to the electric motor vehicle industry of a standard charging plug and socket for the use in question, was brought to the notice of the British Engineering Standards Committee in 1914 by the Electrical Vehicle Committee of the Incorporated Municipal Electrical Association. After consideration it was decided to adopt the dimensions recommended by the Electrical Vehicle Association of America in order that interchangeability should be secured between plugs made in both countries, and the report was issued in December, 1915 (Report No. 74). Early in the present year the Standards Committee (Electrical Vehicle Division) of the Society of Automotive Engineers of America suggested a small modification in the design of the plug which, they found, added considerably to the mechanical strength and did not affect interchangeability. The proposal was supported by the Electric Vehicle Committee of the Incorporated Municipal Electrical Association, and after consideration by a sub-committee of the British Engineering Standards Committee, the modification was adopted. The revised report was approved by the Main Standards Committee in July of this year, and is now issued in accordance with the new policy of the committee in octavo size, price 1s. French, Italian and Spanish translations will be available shortly.

DIPPER DREDGERS ON THE PANAMA CANAL.

*The Three 15 Cub. Yard Dipper-Dredgers—Gamboa, Paraiso, and Cascadas—as Supplied and Used on the Panama Canal.**

By Ray W. Berdeau, Junr., Am.Soc.C.E.

Synopsis.—The object of this paper is to place before the society the result of the writer's study of the design, operation and efficiency of the three large 15 cub. yard dipper-dredgers supplied by the Bucyrus Company for use on the Panama Canal.

The 15 cub. yard dipper-dredgers, Gamboa and Paraiso, were requisitioned by the Isthmian Canal Commission as part of the permanent equipment of the Panama Canal and for immediate use in completing the channel through Gaillard Cut (formerly Culebra Cut). A contract was made with the Bucyrus Company, which stipulated that the dredgers were to be ready for towing to the Isthmus on December 1, 1913, and January 1, 1914. The Gamboa was accepted at Port Richmond, N.Y., on February 16, and the Paraiso, on April 13, 1914. The Gamboa reached the Isthmus on March 16, and was placed in operation on April 4, 1914, being followed by the Paraiso, which arrived on May 22, and started work on June 7, 1914. The total cost of the two dredgers, and the towing, &c., was 573,287.40 dols., to which initial cost should be added 3,092.50 dols. for the Gamboa, and 1,786.21 dols. for the Paraiso, the respective amounts necessary to place them in commission after their arrival.

These dredgers operated so efficiently that the Isthmian Canal Commission placed another contract with the Bucyrus Company for a third dredge, of improved design, called the Cascadas, which was accepted at Port Richmond, N.Y., and successfully towed to the Isthmus, where it arrived on October 21, 1915, practically two months ahead of the promised delivery, and was placed at work in Gaillard Cut on October 31, 1915, at a total cost of 376,180 dols.

The following are the principal dimensions, &c., of the Gamboa and Paraiso :—

	Ft.	In.
Length of hull	144	0
Beam, moulded	44	0
Depth, moulded	13	6
Draught	8	0
Digging depth, below water line ...	50	0
Displacement	...1,730tons.	

One main engine, two cylinders, compound, 16 in. by 28 in. by 24 in.
One swinging engine, two cylinders, compound, 12 in. by 16 in.
One backing engine. two cylinders, compound, 12 in. by 16 in.
Two forward spud engines, two cylinders, compound, 12 in. by 16 in.
One stern spud engine, two cylinders, 9 in. by 9 in.
Two deck winches, two cylinders, 6 in. by 6 in.
Two boilers, Scotch marine type, 126 in. diameter, 138 in. long, working pressure 150 lb.
Two forward spuds, 48 in. by 48 in., and 82 ft. long.
One stern spud, 30 in. by 30 in., and 83 ft. 6 in. long.
Swing circle, 24 ft. in diameter.
Bail pull, 235,000 lb.
Hoisting pull on spud rope due to engine, 88,000 lb.
"Pin-up" pull on single cable, with brake on engine, 160,000 lb.
Capacity of rock dipper, 10 cub. yards.
Capacity of mud dipper, 15 cub. yards.
Capacity of fuel oil tanks, 14,200 gallons.

The displacement of the Cascadas is 2,095 tons, and the hull is 144 ft. long, 55 ft. beam, and 15½ ft. deep Thus, it is 11 ft. wider than the others, making less reactions on the spuds, less metacentric variation when digging over the sides, and it allows the spuds to be inset. The spud-well construction differs from that of the Gamboa and Paraiso, as their forward spuds are placed outside of the hull, with tapering sponsons fore and aft to transmit the reactions to the sides of the hu'l.

Buckets.—The dredgers were supplied with interchangeable buckets of two sizes, one with a capacity of 15 cub. yards and another of 10 cub. yards, for use in rock excavation. Having been placed in Gaillard Cut in rock digging exclusively, the larger dippers have been seldom used; the smaller ones, as supplied by the contractors, were of extra massive construction, but were of insufficient strength to withstand the severe use and the impact from a dipper stick load of 131,000 lb., and were replaced later by the Missabe type of cast manganese-steel dippers. The overall dimensions of the new dipper are 10½ ft. by 9 ft. by 9 ft.; the lips are 3½ in. thick at the bottom bands, and the body consists of a front and back casting with lap-riveted joints at the sides; and, in addition, the lip is a separate casting riveted to the front piece and joined thereto by the rivets of the tooth ribs. Recently, the back and bottom of this dipper has been further reinforced, and the dipper is expected to give greater service and satisfaction than the preceding models.

Cables.—The dippers are hung on a 275-ft. 3¼-in. extra-pliable, improved, plow-steel wire, centre cable, consisting of six strands of 37 wires each, intended to withstand a bail pull of 235,000 lb., the minimum cable life being 3 days and the maximum 35 days. The rapid deterioration of the cables is due to the severe abrasion they receive while at their deeper digging depths (from 35 ft. to 50 ft.), coupled with the deteriorating effects of their constant travel over an undersized point of boom sheave, which is grooved for a wire rope 3¼ in. in diameter, and is about 8 ft. in diameter at the bottom of the groove. The sheaves are of cast steel, with long, heavy, cast-steel hubs, bronze-bushed, to distribute the pressure over the 11-in. sheave pins, pressed into place; the cables, which are the largest in use on dipper-dredgers, are hardly satisfactory for the service required, for which the supplying manufacturers refuse to guarantee them.

Dipper Handles.—The dipper handles on all the dredgers are 72 ft. long overall, and are reinforced top and bottom with 2-in. by 12-in. bars and by 1-in. by 22-in. plates on both sides of each dipper stick. Long-leaf yellow pine is used in the construction of the sticks, and white oak for dead wood. The racks are manganese-steel castings, with a pitch of 3 in., and are about 12 in. wide. They are shrouded to the pitch line, the top of the shrouded portion being ground to form a rolling surface for similar shrouding on the rack pinions. Heavy steel castings are used to connect the dipper hinge frame, and similar castings are used to connect the dipper back braces, which are securely bolted to the end of the handle by a large number of 2¼-in. horizontal and vertical through bolts. The weight of the dipper handle is 81,000 lb., its life averaging about six months, that of the rebuilt handles being three months.

Saddle Block.—The innovation in the design of the saddle block has proved as useful as it is interesting. The slide plate is separated into two parts for assembling on the flanged shipper-shaft, leaving a passage in the middle, which permits the main-hoist cable to run in a straight line from the foot to the point of the boom sheave. This eliminates the usual hump sheave, which is generally placed near the upper end of the boom and is necessary on other dredgers to lift the single-hoist cable clear of the saddle block.

The heavy unit construction facilitates the guiding and holding of the dipper handle in a much more secure manner, and improves the meshing of the racks on the dipper handles with the pinions of the 9½-in. hollow, nickel-chrome-steel shipper-shaft, at times to such an extent that the teeth are stripped from them both. By building a heavier bucket, the dipper handle, saddle block, shipper-shaft and hoisting arrangement offer opportunity for improvement in design, in that the dipper stick would be stronger if it was made of one piece, two main hoisting cables being used, running on each side of the dipper handle, thereby increasing the life of the hoisting cable and also the dipper stick. This dipper stick at times becomes bowed and, due to the sliding fit with the saddle block, necessitates immediate realignment; this could be obviated if a rolling fit was presented, the rollers being supplied with bearings under compression. The shipper-shaft bearings, which are bolted to the top chord of the boom, project so that the flanges of the brake wheels, which are built of steel castings 75 in. in diameter, with a 12-in. face, and bolted to the flanges on each end of the shipper-shaft, engage the bearing boxes when lifted for removal, making an extended operation of changing the shipper-shaft. The brakes are of the double-acting type, and are actuated by a steam thrust-cylinder, the steam valve of which is controlled by a floating lever and operated by a hand lever on the craneman's platform.

Booms.—The booms on these dredgers are 62 ft. long, of the plate-girder type, with curved top and bottom chords. All parts of these booms are supposed to be of ample section to withstand developed stresses which due to the heavy type of work, have been such as to necessitate reinforcement of the different booms that, with complete machinery, weigh 113,000 lb. They are equipped with a steam-operated boom brake, steam shipper-shaft brakes, and a steam dipper trip, the cylinder of which is mounted above the foot of the boom, and is connected with the latch bar on the dipper by an endless wire rope, the circuit beginning at the upper end of the dipper handle, leading around the sheave on the stand just below the shipper-shaft, and thence around the sheave attached to the crosshead of the steam dumping cylinder, which permits dumping in any position. The boom feet are of heavy steel castings, with webs and flanges of such length as to permit adequate riveting. The boom is stepped into a steel casting pivot, formed with sockets to receive the boom feet; the pivot rotates on a heavy cast-steel base-plate, securely bolted to the hull, with its flanges extending over the front of the hull. The pintle is bronze-bushed, and has a bronze wearing plate or washer between the boom step collar and the baseplate, and another bronze bushing and wearing plate is used between the base plate and the centre casting of the swing circle.

Main Engines.—The main engines are specified to work at a steam pressure of 135 lb. while condensing. They are of the horizontal, twin-tandem compound type, with 16-in. and 28-in. cylinders and 24-in. stroke, mounted on heavy, self-contained cast-iron bedplates of the Tangye pattern. The crankshaft is of forged steel, 12 in. in diameter, with journals 9½ in. in diameter and 14 in. long, and with screw-adjusting bearings. The connecting rods, valve stems and the adjustable bronze-shoed crossheads are of steel, finished and arranged for taking up wear. The link motion and reverse gears are omitted on the Cascadas, and are replaced by a steam turning gear, comprising a steam reversing engine geared to the crankshaft with a releasing jaw clutch operated from the engine room. The low-pressure cylinders have piston valves working in renewable cast-iron valve cages, a stuffing-box being incorporated between the high and low-pressure cylinders. The eccentric bearings of the Cascadas are larger than those of the Gamboa and Paraiso, and the Cascadas is equipped with an overhead 15-ton travelling crane.

Hoisting Drum and Gears.—The hoisting drum is of the differential type of cast steel, and is bushed with bronze. The small diameter is 69 in. and the large diameter is 84 in. at the bottom of the grooves, which are for 3½-in. wire cable. The drum is mounted loose on the 16-in. forged-steel main hoisting shaft, having journals 11½ in. in diameter and 18 in. long. Power is applied to the drum by two outside, wood-lined band frictions, one on each side of the drum, both operated by a single steam cylinder 14 in. in diameter, placed at one end of the drum shaft and attached to a thrust spindle passing through the centre of the shaft. The drum is of the usual type supplied by the Bucyrus Company on its dredgers, and has a barrel-like shape, which permits the maximum digging force and the slowest speed when the dipper is excavating and the angle between the hoisting rope and the dipper handle is sharpest; as the rope is wound on the larger diameter, the dipper is hoisted, allowing any desired increase of hoisting speed when the maximum bail pull is not required. The diameter of the drum could be increased, which would reflect in length of cable life. The drum is driven by two heavy spur gears, 12 ft. in diameter, one on each side, meshing with the corresponding pinion of the intermediate shaft. The gear hubs next to the bearings are lined with bronze. The intermediate shaft is driven from the crankshaft through a single gear, which has steel castings rim-bolted to a heavy cast-steel spider arranged for rim replacements without stripping the shaft. The intermediate gear rim is split for easy removal and replacements, and, like the pinion on the crankshaft, has cut teeth. The intermediate shaft is bolted directly on the engine bedplates; the bedplate also contains the drum-shaft bearings, and is of cast steel, forming an extension of the engine bedplate, and is securely bolted to it and the structural base built into the hull.

Swinging Circle Machine and Guide Sheaves.—The swinging circle is of structural steel, 24 ft. in diameter, and mounted on top of the hull truss; connection is made to the boom with two heavy built-up girders, extending out from the circle, one on each side of the boom. The centre is a heavy steel casting, securely bolted to the circle, and has an I-beam rim, reinforced with ¾-in. plates, the jaws being fastened to the boom at the forward ends. Changes have been effected in the rope anchorage of the dredgers by making the swing rope around the circle in four separate pieces with open socket connections, which renders complete stripping unnecessary when the rope is changed. Two 42-in. cast-steel sheaves, on top of the hull truss, grooved for a 2-in. rope, and complete with shaft bearings and 4½-in. sheave-pins, are supplied for guiding the swing rope from the circle to the swinging drum. The swinging machinery is operated by an independent double engine, with 12-in. cylinders and 16-in. stroke, and reversing link gear. The engine and drum are mounted on heavy structural steel bases built into the hull, and the links are reversed by the steam thrust cylinder controlled by the lever which operates the throttle.

Backing Engine.—The backing engine and drum are mounted on a structural steel base built into the hull, and the drum is operated by a separate 12-in. by 16-in. double non-reversing engine. The cast-steel drum (26 in. pitch diameter) is driven by an outside-band friction clutch, actuated by a steam thrust cylinder, 5 in. in diameter, and carries a 2-in. steel rope. The diameter of this drum is too small, as it breaks the strands of the cable, prevents proper reeling, and causes slack on the drum, which prohibits uniform backing of the bucket. The gear reduction between the crank and the 7-in. drumshaft is single, and a band brake prevents the running out of the rope.

Forward Spud Machinery.—Each forward spud is operated by an independent, double, 12-in. by 16-in. engine, with link-motion reverse, which is operated by a steam thrust cylinder controlled by the lever which operates the throttle valve. The spud drums are 42 in. in diameter and are grooved for 2¼-in. wire rope. The Cascadas is "pinned up" and the spuds are lifted by a 2¼-in. wire rope passing around the four sheaves at the top of each spud; the pinning-up ropes are similar to those on the Gamboa and Paraiso, but the spud-hoist ropes run over sheaves which are on a gantry mounted near the spud casings and extending above the highest position of the spuds.

The Bucyrus Company has developed a big improvement in this design, as it dispenses with the sheaves at the lower end of the spuds, where the wire ropes are quickly cut by the sharp stones found in the rock excavation in "the Cut." Wood-lined band brakes, operated by a steam cylinder, are supplied to hold the dredge when "pinned-up," and the spud-tackle rope is taken up by four parts of rope. Each spud engine is connected to its drum by double-reduction gearing of cast steel; and a suitable friction clutch, operated by a steam thrust cylinder, is provided to disconnect the drum from the engine, allowing the dredge to rise and fall with the tide when not in use. The spud drum machinery and engines are supported by a heavy structural steel frame built into, and set far enough from the side of, the hull to permit ready access to the spud machinery on the outboard side of the foundation. The sheaves guiding the spud ropes to the drum have a pitch diameter of 45 in., are cast steel, bushed with bronze, and have annealed forged-steel sheave pins. The stern spud machinery is arranged for a trailing spud that is hoisted by rack and pinion, through two gear reductions, by a 9-in. by 9-in. double engine, placed on and operated from the deck, at the stern of the dredge. The intermediate shaft is fitted with a band brake, to hold the spud in its proper position, and carries a jaw clutch for disconnecting the drum from the shaft and the engine

* Paper read before the American Society of Civil Engineers.

The stern spud is of structural steel, 30 in. by 30 in., and 83 ft. 5 in. long, and is held in place by a sliding-fit arrangement somewhat similar to that of the saddle block. This creates the necessity of immediate realignment when the spud becomes slightly bowed. The forward spuds are of structural steel, 48 in. by 48 in., and 72 ft. long, with 8-in. by 8-in. by ¾-in. corner angles, ¾-in. side plates, and suitable diaphragms, those of the Cascadas, as mentioned, having all sheaves at the top of the spud. As heavy as they are, these spuds have to be removed every 90 days, three being broken in as many days, in one case.

TABLE I.—*Monthly Performance of Dredger Gamboa.*

Date.	Cubic Yards.	Cost of Operation.	Cost of Maintenance.	Total Cost.	Cost per Yard.
1914.		dols.	dols.	dols.	dols.
April ..	32,805	4,446.82	10,798.18	15,245.00	0.4647
May ..	108,185	7,365.53	16,165.11	23,530.64	0.2175
June* ..	123,199	6,764.68	24,279.25	31,043.93	0.2519
July ..	108,896	7,441.27	21,148.06	28,589.33	0.2625
August ..	121,850	7,002.58	14,772.77	21,775.35	0.1787
September	111,355	6,561.27	12,238.25	18,799.52	0.1688
October ..	137,060	7,377.96	9,015.69	16,393.65	0.1205
November	140,905	7,612.19	8,902.44	16,553.81	0.1174
December .	166,092	8,147.03	12,997.82	21,144.85	0.1274
1915.					
January ..	178,370	7,823.27	14,351.67	22,147.94	0.1244
February	149,554	6,308.69	8,939.04	15,247.73	0.1020
March ..	207,870	7,425.32	9,643.36	17,068.68	0.0821
April ..	168,725	7,003.25	10,593.31	17,596.56	0.1043
May ..	165,720	7,599.38	11,839.11	19,438.49	0.1173
June* ..	168,725	7,075.09	11,332.41	18,407.50	0.1091
July ..	171,370	7,376.09	9,421.10	16,797.19	0.0980
August ..	199,425	8,102.46	12,111.33	20,213.79	0.1014
September	280,550	8,263.33	8,455.81	16,719.14	0.0596
October ..	249,515	7,610.10	14,612.47	22,222.57	0.0891
November	260,845	8,280.17	10,431.38	18,711.55	0.0717
December .	266,470	8,877.27	9,624.75	18,502.03	0.0694
1916.					
January ..	232,855	7,515.06	8,590.39	16,105.45	0.0692
February ..	293,230	9,103.00	10,056.95	19,159.95	0.0653
March ..	304,006	9,241.50	10,790.25	20,031.75	0.0695
April ..	263,275	8,896.18	10,460.12	19,356.30	0.0735
May ..	271,235	8,638.56	8,996.67	17,635.23	0.0650
June* ..	304,450	9,127.41	12,003.65	21,131.06	0.0694
July ..	320,190	9,448.95	9,055.02	18,503.97	0.0578
August ..	129,210	6,221.29	8,046.99	14,267.78	0.1108
September	150,175	7,748.87	8,238.84	15,987.71	0.1063

Yardage Excavated by Fiscal Years.

July 1,1913, to July 1, 1914 ..	264,189	—	—	69,819.57	0.3021
July 1,1914, to July 1, 1915 ..	1,825.122	—	—	233,190.41	0.1278
July 1,1915, to July 1, 1916 ..	3,097.226	—	—	226,586.01	0.0731
July 1,1916, to Octo- ber 1, 1916	599,575	—	—	48,759.46	0.0713

* End of fiscal year.

Deck Fittings.—On the main deck, outside of the house, there are two three-drum winches, which are used for moving scows, and are equipped with internal driving engines. Each engine is of the horizontal type, and has two 6-in. cylinders with 6-in. stroke; the throttle valve is in the main steam chest, and also acts as a reversing valve. The drums are steel castings, bushed with bronze, with 24-in. barrels 12 in. long, and equipped with friction clutches of the outside-band type, as well as band brakes. There are 10 double mooring bits, 10 single deck spools, and 16 deck chocks.

Boilers and Fittings.—Steam is provided in the Cascadas by a battery of three boilers of the Scotch marine type, arranged so that any two boilers can be used at one time, the third one being a spare, permitting of blowing down without tying up the dredge, this being an additional boiler to the two supplied, respectively, to the Gamboa and Paraiso. The boilers are constructed for a working pressure of 150 lb. per square inch; each is supplied with two Morrison suspension furnaces, and is equipped with marine pop safety valves, stop valves, pressure gauges, blow-off cocks, &c. The stack is double, and about 50 ft. high above the tops of the boilers. One surface condenser is supplied, having approximately 1,500 sq. ft. of cooling surface, together with an independent air pump and a 10-in. brass runner, centrifugal circulating pump, driven by a separate engine. One 300-h.p. feed-water heater of the closed type and two 7-in. by 4½-in. by 8-in. brass-fitted, horizontal, duplex boiler feed pumps are provided, also a similar pair for general service, one fresh water, 4½-in. by 2½-in. horizontal pump, one 12-in. by 6-in. by 12-in. horizontal duplex brass-fitted pump, and a bilge pump for each compartment. The piping system is very complete, each line having a stop valve to cut it off from the boiler or main, so that repairs can be made at any time without shutting down the system. All the large pipes are flanged, and the steam fittings for 200 lb. pressure and exhaust fittings for 125 lb. are extra heavy.

Tanks.—There are four steel fresh-water tanks in the stern of the hull; two of 30,000 gallons capacity are supplied for boiler feed purposes on the port and starboard sides, respectively. There is an 8,000-gallon tank on the port side for galley use, and a duplicate tank on the starboard side for ballast and trimming. There are two 18,000-gallon oil tanks in the hull forward of the boiler, one on each side of the dredge, and two oil-feed pumps are used to supply oil to the boilers.

Electric Light Plant.—Two 10-kw., 110-volt. direct-current generators, each connected directly to a vertical automatic engine, are provided for lighting the dredger, operating the house lights, the searchlight, and the lights used in night dredging.

House and Cabin Construction.—The main deck-house is 108 ft. long and 41 ft. wide from the front end to frame 48 (about 95 ft.), and 30.4 ft. from frame 48 to after end. The height is about 17 ft. for a distance of 18 ft. from the bow end, and 15 ft. throughout the remaining length. The upper deck over the house is 112 ft. long and 44 ft. wide throughout, projecting 6 ft. 9 in. over the lower deck-house on all sides. Quarters are supplied for 11 "gold" (white) American employees and 57 "silver" (coloured) employees. Three officers' staterooms have hot and cold water service, one berth and single-wall lockers. All other staterooms are fitted with double wooden built-in berths, with two drawers and lockers under each lower berth, double wooden-wall lockers, and wash basins with hot and cold water. The galley and dining-room are amidships, between the "gold" and "silver" quarters; in the latter, 38 standee bunks with canvas bottoms and 38 sanitary steel lockers are supplied. There is also separate modern bath and toilet service on the main deck for both "gold" and "silver" men.

TABLE II.—*Monthly Performance of Dredger Paraiso.*

Date.	Cubic Yards.	Cost of Operation.	Cost of maintenance.	Total Cost.	Cost per Yard.
1914.		dols.	dols.	dols.	dols.
June* ..	69,812	9,002.69	11,458.21	20,460.90	0.2931
July ..	82,203	5,717.11	10,221.48	15,938.59	0.1939
August ..	95,475	6,728.67	20,155.38	26,884.05	0.2816
September	105,470	7,236.62	17,889.63	25,126.25	0.2382
October ..	125,6.5	7,380.00	9,644.65	17,024.65	0.1355
November	139,916	7,938.98	15,110.36	23,091.19	0.1650
December .	144,165	7,824.00	12,371.43	20,195.43	0.1401
1915.					
January ..	176,862	8,111.45	11,380.86	19,492.31	0.1102
February	172,057	5,617.64	9,310.49	13,928.13	0.0868
March ..	134,030	6,395.02	8,740.37	15,135.39	0.1129
April ..	204,250	7,410.48	9,274.15	16,684.63	0.0817
May ..	184,510	7,239.92	10,889.73	18,129.65	0.0983
June* ..	174,685	7,880.58	8,855.95	16,766.53	0.0960
July ..	170,060	8,003.89	9,970.81	17,974.70	0.1057
August ..	203,815	8,064.34	10,748.12	18,812.46	0.0923
September	220,940	7,280.87	10,986.89	18,267.76	0.0827
October ..	291,675	8,859.52	15,502.24	22,361.76	0.0767
November	262,925	8,740.54	9,193.33	17,933.87	0.0682
December .	312,920	9,716.54	10,153.78	19,870.32	0.0635
1916.					
January ..	195,515	7,295.94	8,587.49	15,883.43	0.0812
February ..	236,235	8,710.18	11,975.35	20,685.53	0.0876
March ..	299,155	9,099.70	11,323.76	20,423.46	0.0683
April ..	232,365	8,887.67	10,152.90	19,040.57	0.0819
May ..	306,435	8,649.36	10,871.43	19,520.79	0.0637
June* ..	272,064	9,115.15	11,275.58	20,390.73	0.0749
July ..	233,930	6,418.34	7,192.01	13,610.35	0.0581
August ..	315,915	9,823.62	12,505.83	22,329.45	0.0714
September	268,250	8,921.49	9,029.42	17,950.91	0.0689

Yardage Excavated by Fiscal Years.

July 1, 1913, to July 1, 1914 ..	69,812	—	—	20,460.90	0.2931
July 1, 1914, to July 1, 1915 ..	1,739.228	—	—	228,396.80	0.1313
July 1, 1915, to July 1, 1916 ..	3,004,104	—	—	231,165.38	0.0769
July 1, 1916, to Oct. 1, 1916 ..	818,095	—	—	53,890.71	0.0658

* End of fiscal year.

TABLE III.—*Monthly Performance of Dredge Cascadas.*

Date.	Cubic Yards.	Cost of Operation.	Cost of Maintenance.	Total Cost.	Cost per Yard.
1915.		dols.	dols.	dols.	dols.
October ..	695	427.10	—	427.10	0.6145
November	296,280	9,371.94	10,056.25	19,428.19	0.0656
December	321,065	9,961.47	10,221.35	20,182.82	0.0628
1916.					
January ..	292,675	9,054.96	10,769.15	19,824.11	0.0677
February ..	330,605	8,982.54	9,939.51	18,922.05	0.0573
March ..	309,125	8,796.39	10,723.06	19,519.45	0.0632
April ..	246,786	8,649 02	10,775.53	19,424.55	0.0787
May ..	316.770	8,848.07	10,818.53	19,666.60	0.0621
June* ..	286,491	9,171.57	9,995.13	19,166.70	0.0669
July ..	340,185	9,383.79	10,244.25	19,628.04	0.0577
August ..	203,967	8,135.09	9,481.83	17,616.92	0.0862
September	122,504	6,864.80	5,367.74	12,232.54	0.0987

Yardage Excavated by Fiscal Years.

July 1,1915, to July 1, 1916 ..	2,400,492	—	—	156,561.57	0.0651
July 1,1916, to Oct. 1, 1916 ..	666,656	—	—	49,477.50	0.0742

* End of fiscal year.

The Hull.—The hull of each dredge is of steel. The Cascadas is 144 ft. long overall, 55 ft. wide, and has a mean depth of 14 ft. 6 in. (15 ft. 6 in. at bow at centre, and 13 ft. 6 in. at stern at centre), with a straight taper fore and aft. The deck has a 6-in. camber made by straight lines from the centre to each side.

Operation.—All three dredges are 15 cub. yard machines, built by the Bucyrus Company, in the United States, and have been working until recently in Gaillard Cut of the Panama Canal. The material excavated consisted of hard and soft rock, to a depth of from 35 ft. to 47 ft. When the scows are moored on the port side of the dredge, their loading is sometimes handicapped by the inadequate view obtained by the operator while he works, as direct vision of the mid-scow pockets is obstructed by the structural frame supporting the boom and the port forward spud; these pockets, when empty, necessitate the lowering of the bucket into the pocket, so that the spoil when dumped, will not damage the bottom doors. An arrangement of an ordinary mirror, about 24 in. by 14 in., on the operator's right, helps to a certain extent, but, as the scow in the view does not appear quite natural, the scow strong backs suffer. Reflecting mirrors could be arranged to give a direct full view of the loading section, thereby enabling quicker operation. The Gamboa and Paraiso assisted in raising the drill barge, Teredo, which was blown up and sunk in the channel at the foot of Cucaracha Slide on July 20, 1914—by attaching the main hoist cables to slings and raising the wreck. Tables I, II and III give the yardage of the respective dredges, Gamboa, Paraiso and Cascadas, and the material placed in scows alongside the dredges. The accompanying costs include operation, that is, wages of crew, subsistence of crew, fuel, and lubricants, maintenance—that is, the cost of keeping the equipment in first-class physical condition—and depreciation only. Extra heavy 10-yard manganese-steel dippers were used on this work, the dredgers working continuously in three eight-hour shifts, under the charge of the resident engineer, W. G. Comber, M.Am.Soc.C.E., and the superintendent of dredging, Mr. James Macfarlane. [The dredger Cascadas is illustrated on Plate LI, published with this issue.]

THE MICROSTRUCTURE OF COMMERCIALLY PURE IRON.

A Note on the Microstructure of Commercially Pure Iron Between A R 3 *and* A R 2.*

By W. J. BROOKE and F. F. HUNTING (Stoke-on-Trent).

THE idea of the authors in presenting this note to the members of the Iron and Steel Institute, is that they think it may offer points of interest to all concerned in the elucidation of the properties of pure iron.

During the past few years a large amount of investigation has been made at the works of the Shelton Iron, Steel and Coal Company, Limited, of Stoke-on-Trent, in order to obtain a material from the ordinary basic open-hearth furnace which shall possess the highest degree of purity possible under such conditions. Iron is now being made in which all other elements than iron have been reduced to a very low point indeed; in fact, 99.84 per cent. pure iron is guaranteed; such iron being now placed upon the market under the trade name of "Armco Iron." "Armco," however, possesses the very peculiar property of showing a characteristic red-shortness when subjected to mechanical treatment between certain limits of temperature, and it has been during the attempt to investigate this phenomenon that the points recorded in this note have come to light.

It was observed very early in the history of the process that the occurrence of this brittle phase was of a perfectly regular nature and always appeared between certain fixed limits of temperature, viz., 900 deg. C. and 800 deg. C. The existence of this property was all the more remarkable from the fact that at any temperatures other than within the limits named extraordinary ductility and malleability were the prominent properties of the iron. In fact, when cold its similarity to copper in respect of malleability is quite noticeable. Heating the iron to well above Ac3 and allowing to cool, invariably shows red-shortness on arriving at about 900 deg. C., this phase continuing until the lower point named is reached, when all sign of brittleness immediately vanishes.

On the contrary, heating up to the temperature at which the brittleness is most marked on the cooling down curve, namely, 850 degrees, gives no sign of the phenomenon.

Since the fracture of the metal, when broken in the brittle zone, showed a very coarse and crystalline structure (though the crystalline nature was somewhat obscured by the fact that the high temperature at which fracture occurred caused oxidation and consequent obscuring of the exact nature of the fracture), it was thought that perhaps the material was, in this temperature zone, passing through the same phase as electrolytic iron, which has been shown by Stead and Carpenter to possess the property of assuming a coarsely crystalline structure when very thin plates were heated above the upper critical point and allowed to cool below.

It was finally decided to make a series of experiments in order to see if any change in the microstructure of this material could be observed that would throw some light upon the phenomenon, or point to its cause. Pieces of the iron were therefore taken and heated in a gas muffle to a temperature above the upper critical point, i.e., until they were well into the γ-range. The whole were then allowed to cool very slowly, and as the temperature fell to certain points, pieces were removed in turn, and immediately quenched. Tensile tests were made and observations taken of the appearance of the fracture. Physical tests appear on page 534 in tabular form, and it will be noted that although very different

* Paper read before the Iron and Steel Institute in London.

results are obtained from the static tests at the varying temperatures, yet in no case is any brittleness shown therein, even though the pieces were quenched at a temperature at which, in the hot state, marked red-shortness was most evident.

The microstructures are very interesting (Figs. 1 to 14 annexed). The piece quenched at a temperature above 1,000 deg. C. shows the character of γ-iron with "martensitic" appearance. The crystalline boundaries are well broken up, showing small crystalline grains. As the quenching temperature of the pieces fell, the above appearance slowly altered, the γ-iron effect changing into a more definite ferrite form with crystal grains gradually increasing in size. At about the Ar3 point, here shown as about 900 deg. C., we find a complete change. The ferrite grains have increased considerably in size, and at the junctions of many of the crystal boundaries we find a peculiar structure which is pergrains show at this point a tendency to increase in size, this swelling forces the eutectoid, as it were, into rivers which flow until several meet, forming a lake. Since these lakes occur very frequently at the junctions of three crystal grains, they naturally assume triangular shape, which has been found the most prevalent type evidenced. As the temperature falls the ferrite grains become smaller, the number of rivers or tributaries increase, the lakes are reduced in volume, and the ferrite redissolves the eutectoid at the lower temperatures until all trace of it in a separate existence disappears: the whole structure gaining the appearance of normal ferrite.

The temperatures at which the occurrence and disappearance of the eutectoid occurs coincided so remarkably with the beginning and end of the brittle zone as observed in practice, that it was judged that herein lay the cause of this pronounced red-shortness. Experimpossible so far to determine the Ar2 point of this material even on the most delicate instruments.

There is obviously room for much more research in these very interesting points, and perhaps others who have the time and facilities for investigation may be induced to carry on the work further. With the limited means at their disposal, the writers intend to follow up several very interesting facts that have already come to light. The foregoing, however, is given as an index which may or may not point to a solution of the very much debated existence of β-iron.

The authors regret that the experiments so far have not thrown much light upon the practical side of the question, i.e., the possibility of removing the cause of the brittle zone. Very many experiments have been made to determine if possible what was the exact reason of its occurrence. In one set of quenching tests it was found very difficult to reproduce the eutectoid appear-

FIG. 1.—Heated to 1040°C. and quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 1.

FIG. 2.—Heated to 1040°C. and allowed to cool to 963°C., then quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 2.

FIG. 3.—Heated to 1040°C. and allowed to cool to 939°C., then quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 3.

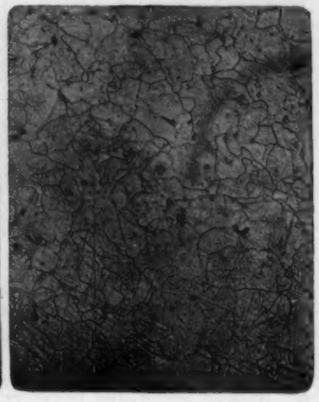


FIG. 4.—Heated to 1040°C. and allowed to cool to 907°C., then quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 4.

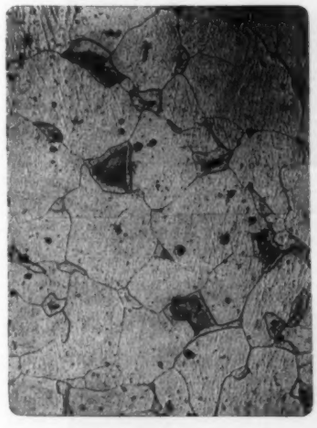


FIG. 5.—Heated to 1040°C. and allowed to cool to 899°C., then quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 5.

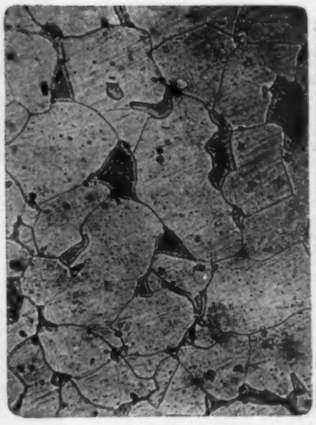


FIG. 6.—Heated to 1040°C. and allowed to cool to 852°C., then quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 6.

FIG. 7.—Enlargement of Eutectoid lake from test No. 6. Magnification: 465 dia. Reduction one-third.

FIG. 8.—Enlargement of Eutectoid lake from test No. 6. Magnification: 465 dia. Reduction one-third. Showing pronounced double boundary.

fectly constant and always possesses the same characteristic. This characteristic is a central structure more or less pearlitic and very clearly defined, surrounded again by a space composed of ferrite, and the whole surrounded again by a definite boundary which connects up with the adjacent crystal grains. A very large number of experiments have been made, and in every case the peculiar structure as shown has appeared in exactly the same manner.

As will be seen from the photomicrographs, these structures within the outer zone are always of a composite character. Various trials have invariably produced the structure always with a double boundary. The central space varies only in the extent of the pearlite appearance, some being rather more so than the others. The peculiar, and we believe novel, fact is that as the temperature at which quenching takes place is lowered, the structure becomes gradually less pronounced, until, just above 800 deg. C., it ceases to exist.

It would thus appear that iron of the relative purity as given here possesses the property of throwing out of solution between the Ar3 and Ar2 points a eutectoid probably composed of iron carbide, phosphide, and sulphide, with possible traces of manganese sulphide and ferrous oxide. In this zone they are thrown out from the ferrite grains to the boundaries, and as these crystaments were made in order to prove that rupture of the material was caused by the weakening of the mass from the occurrence of these lakes of eutectoid. To this end samples were heated and cooled to the desired temperature, and then subjected to bending stresses. Micrographs were taken, but so far no difference has been observed between the stressed and unstressed pieces, except that the stressed specimens showed pronounced slip bands. Further investigation is being made in this direction. The authors have laboured under the difficulty of only having apparatus available in an ordinary works laboratory, and, further, all researches made have been carried out at a time when every energy was absorbed and mind preoccupied in the many and various problems of a practical nature caused through the stress of war conditions.

Investigations have been made to determine the cooling curves of the material, and the authors are indebted to Mr. Percy Tucker for kindly getting this done. The Ac3 point he has found to be 888 deg. C. and the Ar3 point 874 deg. C. It has been found that this is liable to vary with different specimens, and he has recently made experiments with other pieces from various casts, all of which are practically of the same analysis, one of which showed the remarkably high Ac3 point of 941 deg C. Mr. Tucker states that it has been practically ance, and this coincided with a remarkable absence of any spots of "oxide material" in the microstructure. From this it was conjectured that perhaps the structure was dependent upon the existence of dissolved oxide. Samples were taken from the molten bath just prior to tapping, and when it was known that the metal was superoxidised to the fullest extent. The micro-sections showed a vast amount of oxide spots, but the eutectoid structure was merely normal, no more pronounced than when the bath had been deoxidised. On the other hand, attempts were made to deoxidise very completely, and with other agents than the one usually employed; but in every case this eutectoid appeared between the roughly stated points of 900 deg. C. and 800 deg. C. It would be interesting to obtain tensile results of this material actually determined at temperatures at which the eutectoid is thrown out of solution. This would certainly give some further information as to the reason of the brittleness.

The whole question is at the moment very conjectural. Whether the brittleness is consequent upon the method of manufacture, or whether it is a condition of cooled molten iron of practically pure nature, is matter for further investigation. The authors have more or less an open mind on the subject at the present time, but suggest that an explanation may be offered that at

THE MICROSTRUCTURE OF COMMERCIALLY PURE IRON.

FIG. 9.—Heated to 1040°C., allowed to cool to 832°C., then quenched in water at 116°C. Magnification: 125 dia. Reduction one-third. Test No. 9.

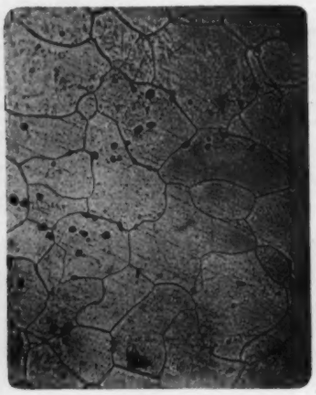


FIG. 10.—Heated to 1040°C., allowed to cool to 804°C., then quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 10.

FIG. 11.—Heated to 1040°C., allowed to cool to 775°C., then quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 11.

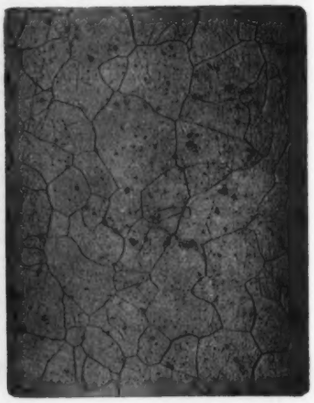


FIG. 12.—Heated to 1040°C., allowed to cool to 680°C., then quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 12.

TABLE OF TESTS, &c., "ARMCO" IRON.

Analysis: Carbon, 0.025 per cent; phosphorus, 0.008 per cent.; manganese, 0.038 per cent.; sulphur, 0.025 per cent.; arsenic, 0.013 per cent.; oxygen, 0.03 per cent. = iron (by diff.), 99.861 per cent.

Test No.	Temperature of Quenching.	Tensile Tests. Breaking Stress.	Tensile Tests. Elongation on 4 in.*	Tensile Tests. Elastic Limit.	Appearance of Microstructure. Magnification, 125 Diameters.	Appearance of Fracture of Test-piece.	Remarks.
	deg. C.	tons per sq. in.	per cent.	tons per sq. in.			
1	1,040	26.0	22.0	16.7	Fine "martensite" appearance of γ-iron.	Silky. Fibrous.	γ-range. Eutectoid soluble. Metal extremely ductile when worked hot.
2	963	25.4	20.0	15.6	Ditto, but less pronounced.	Fibrous, 5 per cent. fine crystal.	
3	932	24.6	20.0	15.6	Normal ferrite, slight decrease in size of grain.	Ditto.	
4	907	24.6	27.0	14.7	Normal structure, small grains.	About 20 per cent. small crystal.	
5	899	24.0	28.0	13.3	First appearance of "eutectoid" structure at junctions of crystal boundaries, with increased size of ferrite grains.	Crystal. Trace of fibre	β-range. Eutectoid insoluble. Brittle zone, if metal worked hot.
6	852	23.1	25.0	12.7	Similar to above, but more pronounced.	Crystalline.	
6a	..	..	..	..	Eutectoid structure magnified to 465 diameters.		
6b	..	..	..	..			
7	832	23.1	33.0	12.1	Similar to above, not so pronounced, crystal grains becoming smaller.	Crystal. Trace of fibre.	
8	804	24.2	33.0	12.7	Similar to No. 6, eutectoid structure disappearing.	60 per cent. crystal, 40 per cent. fibre.	
9	775	22.7	39.5	10.8	Ferrite structure fairly large grains.	20 per cent. crystal, 80 per cent. fibre.	α-range. Eutectoid again soluble. Metal very ductile when hot. Extreme ductility when cold worked.
10	680	22.7	37.0	10.6	Ferrite structure (normal).		
11	575	22.1	38.0	10.2		Fibrous.	
12	Normal	20.0	40.5	10.1	Ordinary ferrite (ditto).	Fibrous.	

* The area of the tensile test-pieces was 0.85 square inch.

temperatures between 900 deg. C. and 800 deg. C. such eutectoid as is formed and thrown out of solution may be in a semi-liquid or plastic condition, causing the crystal grains to be very loosely held together, and so making the structure relatively weak. If quenched in this zone the eutectoid solidifies in position, and in that condition does not appear materially to weaken the mass. This would account for the failure to observe any trace of brittleness in pieces quenched in the critical zone as against that shown when hot.

It might be stated, however, that a sample of Swedish iron of a similar degree of purity to the material under discussion has been found to show a brittle zone practically coincident. The tests made were only practical and previous to the possession of a micro outfit, and unfortunately the particular samples are not now to hand. Further, we have found that iron containing carbon 0.06 per cent. and manganese 0.10 per cent. does not show any brittleness when manufactured in the same way as the material under discussion.

In conclusion, the authors would like to thank Mr. P. Tucker for his determinations of the critical points, Dr. Desch for his valuable encouragement in carrying out the researches, and Mr. W. Simons and Mr. A. E. Tucker for kindly revising the proofs.

THE FIRST IMPERIAL GERMAN ELECTRIC POWER STATION.—Considerable attention has been aroused by the German Empire as such having acquired from the Allgemeine Elektricitäts Gesellschaft the large Elektrowerke power station and the important lignite deposits Golpa-Iessnitz, which belong to the Elektrowerke Company. This latter concern was built by the Berlin Electricity Works, but was taken over by the Allgemeine Elektricitäts Gesellschaft, the two companies being very closely connected. It was stated at the last general meeting of the Allgemeine Elektricitäts Gesellschaft, that the Elektrowerke had not so far fulfilled the expectations of it becoming a paying concern, but as this company was better able to wait for the hoped-for improvement and to defray the necessary heavy outlay, it had been decided that the Allgemeine Elektricitäts Gesellschaft should take it over and develop it so as to become a paying concern. These expectations were based upon the fact that the unfavourable results so far experienced were more the outcome of unremunerative contracts for the delivery of electric energy than that of natural industrial conditions. It was hoped that these unfavourable agreements would be modified or their period shortened; at worst the company would have to bide the time of their expiration in order to make a paying concern of the Elektrowerke. The Allgemeine Elektricitäts Gesellschaft seems now to have arrived at the conclusion that it was better to cut the loss at once and liberate the large sums interested in the undertaking, than to run it for a series of years as a losing concern. The share capital was only small, 5,000,000 marks, but the Allgemeine Elektricitäts Gesellschaft had invested in or advanced to the Elektrowerke additional 40,000,000 marks. The Imperial State has acquired the share capital, the rate of exchange not being mentioned, and the Elektrowerke will remain a limited company, as did the large Hibernia Mining Company when taken over by the State of Prussia. The members of the board of the Elektrowerke will resign their posts, and representatives of the Imperial Exchequer will be delegated to the board. This is the first Imperial electric power station in Germany; but a scheme for exploiting the water power of the Upper Rhine through the medium of the Empire has been under contemplation for some time. The energy from the Elektrowerke is at present needed for important military purposes, viz., in the Imperial nitrogen works, no other suitable power being at present available. This does not quite fall in with the views expressed while the Elektrowerke were still under the control of the Allgemeine Elektricitäts Gesellschaft, the opinion then put forward being that it was far more rational to exploit water power for this purpose. It remains to be seen whether the German Imperial Government later on will transfer the nitrogen manufacture to places where water power can be exploited so as to liberate electric energy from the Elektrowerke for more rational uses, but as the installations are fairly costly the question must in the meantime remain an open one. There is a possibility of the Elektrowerke being so enlarged, that energy can be spared for other purposes, the more so as the peace requirements of nitrogen is likely to fall short of what is wanted during the war. As a matter of fact the Imperial Nitrogen Works do not absorb all the energy from the Elektrowerke, a portion being employed by the Elektro-Salpeter Company.

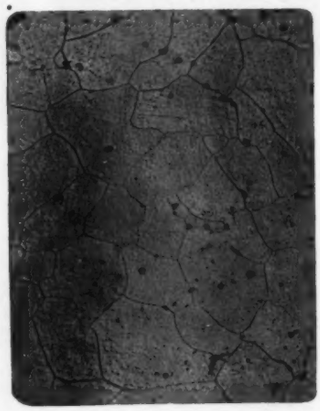


FIG. 13.—Heated to 1040°C., allowed to cool to 575°C., then quenched in water at 16°C. Magnification: 125 dia. Reduction one-third. Test No. 13.

FIG. 14.—Normal (as rolled). Magnification 125 dia. Reduction one-third. Test No. 14

GAS FURNACES: THEIR DESIGN AND MANIPULATION.*

By Arthur Forshaw, M.Sc., Chief Chemist to John Wright and Co., Birmingham.

I believe that no subject could be of greater importance to-day than industrial gas appliances—alike to the designer and manufacturer, to the user, and to the gas industry which supplies them with fuel; and this prominent position is due to the width of range, and the rapidity with which they can be applied to the solution of fresh problems which are daily arising out of war needs.

My object in choosing this subject of gas furnaces is to try and give you, as gas engineers, information as to the types of furnaces in use, the processes for which they are used, and the underlying metallurgical reasons prompting each particular heat-treatment with its appropriate furnace.

Information of this sort can hardly be obtained from catalogues, nor, so far as I know, from any published communications in the gas press. It is an interesting subject to myself; and I offer the following remarks in the hope that it will be no less interesting to the members of your Institution. After all, as far as regards coal-gas, your members are concerned even more than the furnace makers, seeing it is your interest to ensure the adoption of the best types of apparatus and so a continual source of income.

The furnace that has made great strides in the last few years is the crucible melting furnace. Although gas-fired crucible furnaces have been on the market for a number of years, it is safe to say that only within the last four or five years has gas-melting become a commercial proposition; and, indeed, gas-melting as such has so far only touched the fringe of the business. The great bulk of metal in this country is melted by coke. In a recent paper it was stated that the best pit-type coke furnace melting brass has a thermal efficiency of about 5 per cent. Even this low figure is a great improvement on some of the earlier types of coke furnace. For instance, what I might call the old original square coke furnace had an efficiency in the neighbourhood of 1 per cent. The usual way of rating coke furnaces is by weight of fuel consumed, expressed as a percentage of the weight of metal melted. In the best pit-type of to-day this figure is about 30 per cent.—*i.e.*, between 6 cwt. and 7 cwt. of coke per ton of brass; while in the original square type above mentioned it ran about 150 per cent. This low efficiency was due to the fact that the lining of the furnace was merely done by the bricklayer according to his own ideas and without reference to drawings. Obviously, the consumption of coke in such instances is only limited by the width of the fire and the strength of the draught. As the latter may vary from day to day, so the efficiency and output would also vary. High as this consumption is, there was a type of furnace which eclipsed it. It consisted of a large chamber holding four to six pots. These were surrounded with, and buried in, coke. The top of the chamber contained a flue. Access to the pots could not be obtained once the fire had started; so, in order to get full charges of molten metal, they were piled up high with the ingots or scrap, which was thus in direct contact with the coke. Under these conditions the fuel consumption was about 300 per cent. of the metal melted; while the latter, owing to its exposure to gases and coke, contained much oxide and sulphide. In the most modern pit-type coke furnaces, when the lining requires renewing, the old one is chipped out and a complete lining in one piece inserted. In this way, the furnace always starts with its new lining of the correct size. Several furnaces of this type are connected up to one common flue; the draught to each being controlled by the opening left for the purpose in the lining. Fuel consumption is reduced by the use of special bars which also allow of the easy withdrawal of clinker. Without some special arrangement of this sort, bars become clinkered-up, with the result that uneven burning of the fuel takes place. Nearly all the best pit furnaces are built square. This creates a sort of reservoir of fuel at the corners, and also allows extra large lumps of coke to be raked into the corners without any liability of damaging the pot by forcing them down a circular combustion space of constant dimensions. Further, it allows of easier introduction of the tongs. These advantages have to be weighed against a slightly greater efficiency for round furnaces—providing the coke is graded properly. Such in brief are the coke-pit furnaces against which gas has to make headway.

There remain, however, the coke tilting-furnaces; and these are dangerous competitors in their own way, for they claim to attain a thermal efficiency of approximately 15 per cent.—*i.e.*, they require only one-third of the coke of the pit-type to do the same work. This leads me to a very important point, and one which I wish to emphasise. It is that we see far too much attention drawn to the consumption of fuel, and too little to other factors which enter into the melting of metals. It might be argued that as you are concerned in providing the fuel, that factor is of transcendent interest to you. This is true; but unless the apparatus to which you supply fuel is satisfactory in regard to the other factors, your market for fuel will soon disappear. It is, of course, the manufacturer of the gas-melting furnace to whom you must look for satisfactory apparatus; while he, on his part, must look to you for fuel which can compete with its rivals.

Passing on to discuss the other factors, we can briefly comprise them under the headings of linings, crucibles, labour, and rate of output.

With regard to linings, we are faced with the fact that when furnaces come to be lined, the ordinary coke furnace costs less than the gas furnace, for the reason that in coke furnaces a lower class of refractory can be used than in gas furnaces. In coke furnaces, the bricks are in contact with the coke. They are also subject to corrosion from the ash and to erosion due to the continual rubbing of the coke as it passes down the combustion space, and therefore, to enlargement of the latter, but up to a certain point this does not matter much; it raises the fuel consumption somewhat; but in normal times coke is comparatively cheap. In the gas furnace, on the other hand, the combustion space must be kept constant within narrow limits, or the consumption of comparatively costly fuel rises materially. All the time, however, unless care is taken, the lining of a gas furnace is subjected to the effects of any metal which may be spilt over the sides of the pot or during charging. The action of such spilt metal is very destructive; the metal first oxidises during the times the gas is off for the pouring, and the basic oxide produced afterwards attacks the acid brickwork with resultant formation of slag. This, of course, increases the combustion space; while if the slag be not removed at sufficiently frequent intervals, it may make its way up to the burner level, and either deflect the flame or completely block up the burner ends.

Again, unless certain precautions be taken in designing the furnace, the same thing may result from the slag running down the furnace wall and dropping on to the burner. To prevent such blocking of the burners, we have tried burners at the top of the furnace; but so far the disadvantages appear to outweigh the advantages. I can say no more on this point, as the experimental work is still proceeding. It follows that the linings should be selected with a view not only to resistance to heat but also to slag corrosion. Our experience is that most of the spilling of metal is due to careless stirring; and as it is too much to expect that this will ever be entirely cured, it is essential that the gas furnace be provided with means of removing any slag formed in this way. If it be not removed, the corrosion of the remaining brickwork is much facilitated. In a case where slagging was neglected, I have seen the slag form a pool reaching to a higher level than the top of the pot-stand, while the shape of the furnace from cylindrical had become nearly spherical. Under such conditions even if the burner be not interfered with, the gas consumption may easily double or treble itself. Attack by slag on the linings is much accelerated by temperature, so that the higher the temperature at which the metal must be poured, the greater the care that must be exercised in trying to exclude spilt metal. There is another aspect of the spilt-metal question in relation to temperature that is of special importance to gas-melting. One of the points in favour of gas-melting, as compared with coke, is the possibility of increased output by the former for a given size of plant. This increase may be a very substantial one and amount in some cases to 100 per cent., though more frequently it ranges from 50 per cent. upwards.

Parenthetically, it may be pointed out that increased rate of output means that to reach a given figure, less plant is required, and therefore less capital outlay. To obtain this increase, however, necessitates, among other things, raising the temperature of the combustion space, because the increased flow of heat necessary through the walls of the pot to obtain the output is, of course, made possible by what I may call an increased "head" of heat—*i.e.*, higher temperature; and so again the greater the output the greater the care that must be taken to exclude spilt metal. That temperature itself is not sufficient to damage our linings, we proved by running one of our large "Lip-axis" tilters without any metal in the pot for a week continuously—stopping only for short periods to represent the ends of the normal shifts. Under these conditions, the temperature was raised very much above anything that would be experienced in practice. The lining, on examination, proved to be in practically the same condition as at the start of the test, and quite without signs of fusion or running, except in one place, which was not due to failure to withstand the temperature, and which made the experiment still more valuable, viz., a small piece of iron lodged on the brickwork melted by accident. At the high temperature of the furnace, this has run down the furnace wall and cut a channel in the surface of the lining right from the top to the bottom, where it has finished up in the form of slag.

To return for a moment to the preservation of linings—I have mentioned that suitable means must be provided for getting rid of the slag at frequent intervals—how frequent depends on the care taken by the man in charge of the furnace. In some cases, it must be done at the end of each shift; but with proper attention during charging and stirring, it should not be required so often. It has been the practice to try and get rid of the slag by leaving a hole in the lining at the bottom of the combustion space, communicating with a channel leading outside the furnace. This arrangement, however, is useless. The slag formed is so viscous that it will with difficulty flow into the hole. If it does get there, it solidifies immediately it is out of actual contact with the flame, and the hole becomes blocked. The solidified slag must then be chipped out; and in the doing of this the hole becomes enlarged. In the result, the slag is not satisfactorily got rid of; the furnace lining is damaged by the chipping; and loss of heat occurs through the hole. To improve on this, we introduced a furnace bottom consisting of two semi-circular iron doors hinged on the outside and closing on to a bridge. When open, the furnace had a full through-way into the pit, except for the bridge, and the slag could be knocked down from above while still hot. The doors, before closing, were covered with fireclay. They were held in the shut position by means of iron wedges, which have to be knocked out from underneath before they could be again opened. When closed, the pot-stand rested directly on the firebrick bridge, which, in turn, was supported by a cast-iron or steel strap—the pot, of course, resting on the stand. Sometimes the space between the stand and the furnace wall was filled with broken brickwork. Since then, experience has shown that this method of holding the doors could be bettered, and our present pit furnaces have a wheel and shaft at the side. By turning the wheel which projects above the floor level, the bottom can be dropped without going down into the pit to remove wedges. When it is closed, the wheel is kept in the correct position by means of a ratchet and pawl.

We are often asked what life may reasonably be expected from a furnace lining; and we are bound to reply that "it depends." It is, in the first place, difficult to get definite figures; for we are, as a rule, not in a position to follow the performance of a furnace in an outside foundry for a long enough time. Sometimes one sees estimates of, say, six months or a year; but time in this connection conveys no meaning. We prefer to calculate on the number of melts obtained; and this will, of course, depend on the quality of brick. The users should be guided by the furnace manufacturers in this matter. A figure of 500 melts for small pit furnaces melting gun-metal or brass is not unreasonable; and with care there is no reason why this should not be as high as 800 melts, particularly for brass, while for aluminium it should be considerably more. Naturally, the quicker the rate of output, the greater the wear and tear on linings. On the other hand, continuity in melting makes for economy, as every time the furnace is cooled down and reheated, there is extra wear and tear of the linings. It is well worth considering the expedient of paying furnace operators a bonus on the life of the linings. This general question of getting large outputs at the expense of frequent renewals of plant has been discussed in connection with many different sorts of apparatus and machinery, and can only be decided after experience. In general, it would appear that speeding-up production pays; but each furnace must be specially designed for the particular purpose in view. For instance, a cupro-nickel furnace is supplied with much increased burner power, and is more perfectly heat-insulated; and such a furnace would not be economical to use for brass. On the other hand, a furnace designed for brass would hardly get cupro-nickel to a sufficiently high temperature; and, if it did, the consumption of gas would be unnecessarily high.

Having dealt with some aspects of crucible furnace linings, I will pass on to discuss the second factor mentioned, which was pots or crucibles; and this again may be a serious item unless due care is taken. It does, however, repay attention; and a few notes will help to show in what directions to work for the best results. In the first place, a new pot should be carefully annealed immediately prior to use—14 days steady annealing at 150 deg. C. is not too much. This, of course, applies to crucibles for coke or oil furnaces also. It helps very greatly if the pots are stored in a warm, dry place, *e.g.*, firms who, in addition to brass-melting, do their own rolling and annealing, find the top of the annealing ovens a convenient place; while foundries often store the pots in core ovens, which is good practice. Such procedure can take the place of the annealing mentioned above; the main idea being slowly to get rid of all moisture in the material of the pot. Should this not be effected, the pot will probably "bump"—that is, a piece will flake off from the wall and render the rest of the pot useless. This may happen at any time during the first heat, where annealing has not been properly done. Usually, if the pot survives the first heat, it will last for its normal life.

I will now take some further points affecting the life of crucibles. In gas-melting, the correct setting of the gas and air in relation to one another is primarily made in order to effect the most economical melting; but another reason for taking particular care of the quality of flame is that the crucibles are made of a mixture containing a large amount of graphite. There is no need to dwell on the effect of an oxidising flame on such material. In short, the graphite is burned away, and the pot loses its strength. The same effect may be observed more locally if the burner is of such design that the air jet can play on to the pot before being properly mixed up with the gas. The effect in both cases is to cause the pot to scale—flakes of claywork, from which the graphite has been burnt out, come away from the sides, and the pot is very soon useless. This effect is often produced by fluctuation of gas pressure. The flame may be set correctly in the first place; later on the gas pressure may drop, and in a few minutes the damage is done. In one case I came across, the average life of the pots was increased by five melts simply by installing a good gas-governor. Another cause of this flaking or scaling is when, owing to neglect of slagging-out, a partial stoppage of the burner orifice occurs. This throws a back-pressure on the mixture of gas and air, with a consequent decrease in the amount of gas injected by the air, which latter, being under positive pressure, is scarcely interfered with, and thus becomes in excess. Scaling of crucibles, it should be noted, is also generally an indication of oxidation troubles in the metal.

A further cause of short life of pots is occasionally met with, and that is corrosion on the inside of the pot at the level of the molten metal. This is due to the action of fluxes. At present, it is a matter of controversy as to the exact reactions occurring, because some fluxes appear to attack gas-heated crucibles more than coke-heated ones, and others *vice versâ*. At all events, the trouble is often met with, and is annoying, because, with the exception of a ring of corroded surface, round the top inside, the pot is perfectly sound. The

* Paper read before the Manchester District Junior Gas Association, November 3, 1917.

only advice that can be given at the moment is to try the use of different fluxes, and to limit them to as small a quantity as is permissible; also to remember that a perfectly even flame of the correct quality seem to have a beneficial influence on this inside corrosion. Generally speaking, one finds each particular foundry has a favourite flux of its own; the most usual for brass and copper alloys being pearl-ashes, fluor spar, potassium sulphate, salt cake, common salt, nitre, argol, borax, glass, &c. Charcoal is much used—not, of course, as a flux, but as a preventive of oxidation.

Life of Crucibles.—All these causes of failure in pots, with the exception of scaling, apply to coke-heated crucible furnaces no less than to gas-heated ones; and the question arises, after the presentation of such a formidable-looking list, as to what life may be reasonably expected of the pots. Naturally, this varies greatly with the metal being melted, and the usage to which they are subject. Small pots last longer, as a rule, than large ones, and pots in tilting furnaces longer than those in pit furnaces—the life of the latter is shorter on account of the handling by the tongs to which they are subjected.

To mention definite figures, I know one brass foundry where the average life of coke-fired (60-lb.) crucibles was about 30 to 35 melts—a figure which appears fairly to represent ordinary coke practice. For these people we installed a battery of 60-lb. pit-type air-blast crucible furnaces, and now average 80 to 90 melts per pot. In fact, I have seen pots after they have done 100 to 105, and even 110 melts, that appeared good for several more melts, but had lost shape through the continual pressure of the tongs in pouring, and had been discarded for this reason. In another works, where our 300-lb. tilters are in use melting brass, this foundry regularly obtains 100 melts per pot; and the firm assure us, in spite of our original scepticism, that they have attained 196 melts per pot. They have a good method—they pay the workman a bonus on every melt per pot above a certain number. It is only fair to say that in both the above cases high pouring temperatures are not necessary, and results like this could not be obtained with gun-metal and cartridge metal, which have to be poured at much higher temperatures. In the melting of aluminium, on the other hand, a high figure should be obtained. Only a few days ago, in a works where we had installed several 600-lb. tilters, the foundry manager informed us that he was obtaining 150 melts per pot, and was very satisfied with such a result. One of the metals that causes the shortest life of pots is cupro-nickel. This alloy has to be raised to a temperature of approximately 1,370 deg. C. before pouring; and as the surface of the metal must be protected by flux, long life can hardly be looked for. In coke-melting, using the 250-lb. size (pit-type), the average life is four melts. In a large installation made by us, this size of pot is giving an average of about 14 melts per pot; while with the 60-lb., size an average of from 18 to 19 melts per pot is obtained.

Before leaving the matter of pots, I would say that a pot always seems to give longer life if it can be made to glaze over the outside. Glazing very often occurs without taking special steps to ensure it—in fact, it happens in a gas furnace when the setting of the burners and conditions generally are correct. But sometimes reagents, such as water-glass and the like, are painted on the outside of the pot before use. The glaze protects the graphite from oxidation. There is a further cause of damage to pots that should be noted, and that is due to careless charging. If two cold ingots, for instance, be wedged together, they will expand as they heat, and often burst the pot or damage it severely.

Gas Crucible Furnace.—The third factor I mentioned was labour. On this point I can only give you some general facts. Coke furnaces necessitate the storage and handling of fuel, the disposal of ashes, and the reclamation of metal from them; while gas furnaces merely require the starting of a blower and the manipulation of two cocks. In the light of what I have already said with regard to the care of linings and crucibles, it will be understood that, to get satisfactory results, reasonable but constant vigilance on the part of the workmen is necessary. The gas-fired crucible is a very satisfactory piece of apparatus when properly used. But just as one would not take an ordinary carter and make him one's motor-lorry driver without training him, so the labour employed on gas-fired crucibles requires some training and experience before it can get the best results from such plant, although the men may have had years of experience of coke-fired pots. I find very often that such men are inclined to make difficulties. By long use the conduct of melting by coke and its precautions have become instinctive to them, and when they turn over to gas they have a different set of conditions to face, and must think before they act. This no doubt is not easy for them; and they are at first inclined to visit on the plant the failures which, as you see, are not due to it. Consider for a moment if these men had been brought up to gas-melting, and had been then required to turn over to coke-melting, how much more irksome they would have found it! After all, the coke furnace calls for more manual exertion; while the gas furnace saves this at the expense of a slight further call on the mental functions. To give only one instance, how much hotter work it is removing a crucible from a coke furnace, still containing the incandescent fuel, than from a gas furnace where the fuel is turned off while pouring is in progress. However, our experience is that, after a time, the men get to like the gas furnace better than the coke furnace.

Fuel Consumption.—Having now briefly considered some of the points, due attention to which will promote the success of gas-melting, we may pass on to consider actual fuel consumptions. As I have already remarked, this is the point to which exclusive attention is generally drawn. It is difficult to select figures which correctly represent average practice. Some founders require their metal much hotter than others; and to quote figures which could not be substantiated for any particular operation is to court disappointment. It might be argued that one should quote figures for definite pouring temperatures, with the appropriate increases for definite increments of temperature; but the difficulty is that so very few founders know what their pouring temperature is. They know when they have attained it, but not its figure on the scale. Nor is this to be wondered at, seeing that the types of pyrometer for this particular work leave much to be desired.

Laboratory versus Foundry Figures.—However, to pass on to the figures. I have the results of the melting tests carried out at many foundries. And let me remark here on the difference between tests carried out at the instance of, and in the works of, the furnace manufacturer, on the one hand, and those made under actual foundry conditions on the other. In the first case, everything is subordinated to the laudable desire to get a low melting figure. The life of linings and crucibles is not a question; for there is no possibility of getting information under such conditions. Advantage then is taken, and rightly so, of every circumstance that will help towards the end in view; and the result may be considered as the best possible. In a customer's foundry, on the other hand, very different conditions prevail. In the first place, one may have the inexperience of the workmen to contend against. One may melt a charge and find it cannot be poured immediately owing to a sufficient number of moulds not being ready. Gas must therefore be used to keep it at a suitable temperature till the moulds are ready, or there may be a practice of knocking off for meals, irrespective of batches of metal getting ready, and, further—and also militating seriously against good melting figures—the metal may be asked for at very high temperatures, sometimes unnecessarily high, merely because that particular foundry has been used to such heats in the past. Take, for example, gun-metal. The Admiralty mixture is 88 copper, 10 tin and 2 zinc; and the usual requirement is to specify a breaking load of not less than 14 tons per square inch, with an elongation of at least 7.5 per cent. The difference between results obtained may be illustrated by reference to the following figures giving the cubic feet of gas per pound of metal melted:—

Gun-metal.

	First Melt. Cub. ft. of Gas.	Second Melt Cub. ft. of Gas.	Average over 12-hour Shift. Cub. ft. of Gas.
Foundry A ...	9.03	5.93	5.0
Foundry B ...	7.42	3.98	3.37

These melts were carried out at quite different foundries under the eye of the same observer in each case. The treatment of the metal and pouring temperature were, of course, determined by the foundries concerned; while the other possible variable condition, viz., the calorific value of the gas, was also out of control of the observer. This latter may account for some of the difference in the melting figures, but in my opinion, and after due consideration of all the facts, not for much of it. The main reason for the difference in the figures quoted was the pouring temperature of the metal.

Another cause of wide difference in the melting figures for the same metal is the physical state at the commencement. To take gun-metal, again, it may be put in the pot in the form of ingots of the alloy; and this will give the lowest possible melting figure. Very often, however, the alloy is prepared from its constituents. In this case, the copper is melted first; being put in the pot as ingots of virgin copper. It is fairly clear that, as the melting-point of this metal is higher than that of the alloy, while the zinc and tin, or about 12 per cent. of the whole, cannot be preheated on account of their low melting-points, more gas will be required to make the alloy than to melt it. The more finely-divided the metal is, the more gas it requires to melt it. We usually find ingots are the easiest to melt. After them, heavy scrap-like runners—in fact, between the two there is not much difference. Light scrap takes rather more gas; while swarf may need double, or often treble, the gas necessary for ingots. In general practice, apparently, mixed charges are fed indiscriminately; but from our experience we consider it best in gas practice to charge the lightest scrap first, the heavier next, finishing up with the heaviest.

The foregoing remarks refer to any metal or alloy by itself. Very often when making alloys from the virgin metals, a percentage of scrap alloy resulting from a later stage in the manufacturing process is used to make up the full charge. For instance, in making cartridge brass, 30 per cent. to 50 per cent. of scrap comes back from the blanking stage to be remelted. This has a lower melting-point than the copper; and by charging some of it before the copper ingots, the latter are assisted to melt by conduction from, and by the solvent action of, the liquid from the scrap of the more easily-melted alloy. Without this contact the ingots must first be melted very nearly entirely by radiation from the pot wall, as they only touch the pot at a few points. Many small economies may be made in this and similar ways. It should be borne in mind, however, that judgment and experience are necessary in making use of such "wrinkles." For instance, any small gain of this sort may be more than counterbalanced by loss of zinc if brass scrap is put in and exposed directly to the flame; for zinc is volatile at a very low temperature.

As regards further figures for various alloys and metals, the appended table is interesting; and the results are the more valuable as they are all figures obtained in the foundries of independent firms, and include no purely laboratory tests.

I have already given a slight sketch of some of the types of coke furnaces with which the gas furnace has to compete. If we look at gas-furnace development for a few minutes, it will not only be interesting from an historical point of view, but will give some idea of how figures have been brought to the present level. The first gas-heated crucible I can call to mind was one in which I used to melt small quantities of copper for laboratory purposes. In this furnace, the burner was so placed that the flame struck the crucible directly, *i.e.*, the horizontal axis of the burner would pass through the vertical axis of the pot and at right angles to it. This type was later superseded by that having the axis

Some Figures Representative of Works Practice.

Melting.

Operation.	Size of Crucible.	Average Cub. ft. of Gas per lb. of Metal.	Average Time per Melt.* Min. Gross.	Net.
Melting common brass ingots and scrap for castings, 60/40	60-lb. pit	2.40	35½	25
Making gun-metal for castings, 88/10/2	100-lb. pit	3.37	48½	39
Making cartridge metal strips, 70/30	300-lb. tilter	3.54	72	50
Making cupro-nickel strip, 80/20	60-lb. pit	8.5	59	53
Melting aluminium	600-lb. tilter	3.2	49	34
Making 70/30 cartridge metal	600-lb. tilter	3.0	93	81

* The difference between gross and net melting time represents pouring and charging, and will vary in different foundries according to the rate at which the moulds can be poured.

Annealing.

Operation.	Load.	Duration.	Cub. ft. ton.
	tons.	hours.	
Annealing high-speed steel..	3½	8	3,000
Annealing steel	3½	15½	6,000
Annealing cast-iron parts packed in filings in boxes	lb. 2,000	3	3,360

of the burner tangential to the circumference of the pot or to the inside of the furnace; and practically every crucible furnace burner for other fuels than coke is now arranged after a similar fashion. An air-blast burner of the ordinary blow-pipe type was the burner first used in the tangential position. Later on high-pressure gas began to be experimented with.

In this system the gas is usually compressed to approximately 12 lb. per square inch; and at that pressure it is capable of injecting the air necessary for its complete combustion into the furnace from the surrounding free air against the back pressure of the furnace itself. We had a large experience at the outset; and as a result we were led to the conclusion that it was not a very satisfactory method. We found it unsatisfactory in respect of gas consumption and of output. In a recent paper dealing with high-pressure gas, foundry results are given over long periods; and these fully confirm our experience. In output, they show, for instance, for 60-lb. furnaces, an average time per melt of 1 hour, and a yearly output per furnace of approximately 60 tons—that is, 2,240 melts per annum. In one of our 60-lb. furnaces, we get an average time per melt of 35 minutes to 40 minutes, and approximately 4,000 melts per annum, or over 100 tons of metal. In gas consumption they show 5 cub. ft., and upwards per pound of metal melted for high-pressure gas; while for the same metal we find in our furnaces a consumption under foundry conditions of 2 cub. ft. to 3 cub. ft. per pound.

The nature of the advance we have made may be summarised in the improvements to burners, and the arrangements for preheating the metal. These are the improvements that show in the melting figures; but there are others which show only during works' practice over long periods—such as the arrangements for cleaning slag from the furnace already referred to; improvements in the quality of the linings to stand the attack of oxidised metal; and the generally increased life of the furnace and crucibles. These improvements are due partly to design of the furnace and partly to the Wright-Brayshaw burner. This latter is so designed that it gives as nearly as possible a perfect mixture of gas and air and occasions an intense combustion, if required, by means of which very high temperatures may be obtained. Anyone familiar with gas-furnace work will appreciate this when I say that by its means we are able to melt pure Mond nickel with perfect ease.

Perhaps the most striking advance in the last year or two has been in the construction and use of arrangements for preheating the metal. In ordinary coke practice, this is not done; but we soon formed the view that, with a fuel like coal-gas advantage should be taken of all the heat that could be reclaimed from the products of combustion. For this reason, we introduced a preheater on our pit furnaces (we already used them on our tilting furnaces); and the result is very satisfactory from the point of view of gas consumption.

There are, however, other results that require mention; and I will refer to them shortly. In practice, apart from laboratory tests, the use of an efficient preheater will often reduce the gas consumption by (roughly) one-third. It is necessary, however, to ensure that

should some part of the metal be heated more than others and run at the edges, as often happens, these small amounts of molten metal should be directed into the pot; otherwise they lodge in the preheater or run down the furnace linings with the same result in each case, viz., corrosion of the brickwork. After preheating of the metal, one naturally turns to recuperation of the air or gas, or both. In small furnaces the advantage of this is not so apparent in practice as calculations might lead one to anticipate. The specific heat of air or coal gas is a very low one, which means that a considerable rise of temperature only accounts for a relatively small quantity of heat. This means that, to be really useful, the preheating must be carried to a high temperature. For instance, 1 cub. ft. of air raised from ordinary temperature to 1,000 deg. C. contains, roughly speaking (and disregarding any increase of specific heat at high temperatures), 35 British thermal units, and further occupies, roughly speaking, when heated to that temperature, four to five times its original volume. It will be at once apparent that for a given pressure, a jet which starting cold will pass the correct quantity of air, will be inadequate when the temperature is raised by the recuperation. The same reasoning applies to the gas. In an ordinary burner then, where the injection of gas by air is relied on for obtaining and maintaining the correct mixture, the conditions of equilibrium are considerably upset if one or other constituent be preheated; and if both be preheated to the same degree special precautions have to be taken to ensure the requisite volume at all states of the preheating. Another consequence of the low specific heat is that the exposure to an environment at lower temperature of even a few inches of the pipes conveying the preheated gas or air will cool down the gas or air with loss of practically all the heat that has been imparted to them.

Another consideration is worth mentioning. When iron is exposed to the action of gas or air or products of combustion at high temperatures, it suffers rapid deterioration. As a result of this, advantage cannot be taken of the full temperature to which recuperation might otherwise be carried. In spite of these considerations, we have made many experiments with recuperation on crucible furnaces. One form we tried consisted of a 60-lb. furnace with a chamber built round a considerable length of the gas and air pipes, including the junctions of the latter with the burners themselves. This chamber was heated by the products of combustion coming from the metal preheater, which was also a covered-in chamber. We had a very searching test of this furnace in an independent foundry, which already used similar gas furnaces of our make but without the gas-and-air recuperator. I have the exact gas figures for a week's run under foundry conditions, and a comparative week's figures on one of the furnaces without recuperator. The results showed there was little to choose between the two types of furnace. This does not prove that recuperation has no value. It shows that, under the particular conditions of this test, the value was not apparent in the melting figures—another of those cases where laboratory figures are not borne out in workshops practice.

I remarked in discussing metal preheating that there was another side of it that I wished to mention. This is of outstanding importance; and it may, in a word, be put down as oxidation. In the great majority of cases crucible furnaces are used for melting or making some alloy or other of copper. Copper is a metal that is easily oxidised. It forms not only the black oxide CuO, with the appearance of which we are all familiar, but also the reddish cuprous oxide Cu_2O; and it has the curious property of forming a well-defined series of alloys with this its own oxide. It is stated that in copper itself unless the amount of Cu_2O present exceeds 2.25 per cent. (equivalent to 0.25 per cent. of oxygen) it is not injurious, and, in fact, copper from which all traces of oxygen have been removed, i.e., overpoled copper, is incapable of being worked. I well remember annealing some copper strips in various materials; one of which was charcoal, and the strips after this charcoal treatment could be broken across by bending once in the fingers. In other words, some small amount of oxygen should be present, say, about 0.06 per cent.

In coke-melting where preheating is not resorted to, and where often a lid is used on the pot, there is not so much tendency to oxidise the copper as in gas-melting, where the products of combustion are in contact with the metal in the preheater. Consequently, unless care be taken, too much oxide may be formed. In copper-melting, this necessitates poling the metal or the addition of cupro-silicon as a deoxidiser before pouring. In making alloys, however, the case is different. In brass-making the zinc itself acts as a deoxidiser; and perhaps the only precaution to be taken is to ensure that particles of zinc oxide be not retained in the cast metal. In bronze or gun-metal rather different conditions prevail. In the usual gun-metal already mentioned, 2 per cent. of zinc is added to the copper; and this acts as a deoxidiser and softener. But if much oxygen is present, it cannot be effective, for theoretically 2 per cent. of zinc is only capable of removing about $\frac{1}{2}$ per cent. of oxygen. Where the zinc does not remove all the oxygen, it means that, when the tin is afterwards added the oxide of this metal, SnO_2 is formed; and it has two deleterious effects, Firstly, the tin oxide is very infusible, and forms a pasty mass even at temperatures so high that nothing can be seen in the furnace by the naked eye; and if the metal be then poured, portions of this oxide are trapped in the castings, rendering them unsound. Secondly, the tin thus used up to make oxide prevents the alloy from being of the correct composition to give the requisite mechanical properties. Thus, gun-metal containing 10 per cent. of tin consists on cooling of a mixture of two different copper-tin alloys, the first of which is known as alpha copper-tin, and is a solid solution of tin in copper containing up to and not more than 9 per cent. of tin, and the second of which is called delta copper-tin and consists probably of a compound Cu_4Sn, containing about 32 per cent. of tin. The latter compound may be seen in photomicographs of gun-metal as a lighter-coloured constituent, in between the masses of the yellower alpha copper-tin. If, however, the amount of tin be diminished below 9 per cent., all the tin goes to form the alpha constituent; and the second, or delta constituent, cannot be formed, as roughly $\frac{1}{2}$ per cent. of oxygen in the copper is sufficient to oxidise 2 per cent. of tin to SnO_2—thus bringing about the conditions mentioned. It will be seen how easily oxidation of the copper during the melting can upset the resulting alloy.

In mentioning these difficulties that occasionally arise, I must say that in other cases of melting the same metals with the same type of furnaces they are not met with, and one is driven to the conclusion that local conditions are responsible, by which I mean the original brand of virgin metal used, flux, gas quality, and manipulation generally. The problems as they confront one are intensely interesting; and I think I have said enough to indicate that to tackle them—as the gas-furnace exponent is bound to do, for any fault is always attributed to the gas-furnace—requires not only a knowledge of gas-furnaces but of metallurgy as well. A case such as I have outlined above was proved to be curable by poling, which is tedious and arduous, or (alternatively) by adding phosphor copper in the correct quantity—the phosphorus, with its well-known avidity for oxygen, removing the latter with formation of the oxide of phosphorus. It must be again noted that the use of such expedients requires judgment—an excess of phosphorus would be as bad as the original fault.

Before leaving this part of the subject another influence which may alter the mechanical properties of the alloy must be mentioned. I refer to the pouring temperature. I have already stated that Admiralty gun-metal must show a tensile strength of at least 14 tons per square inch, and an elongation of 7.5 per cent. These figures can be readily obtained; but they may be greatly modified by the casting temperature. For instance, Longmuir gives the results of three tests from the same batch of gun-metal as follows:—

	Pouring Temperature. Deg. C.	Maximum Strength. Tons per sq. in.	Elongation. Per cent. on 2 in.
1 ...	1,173	8.4	5.5
2 ...	1,069	14.8	14.5
3 ...	965	11.0	5.0

And during our own investigations, we have incidentally confirmed these figures. As the judging of temperature by the eye is somewhat different in gas furnaces compared with coke furnaces, it is easy for the inexperienced workman to spoil the metal before he has become accustomed to the altered appearance.

(To be continued.)

FERRO-CONCRETE PIERS IN JAPAN.—We read in *The London and China Telegraph* that a Bill to construct two large ferro-concrete piers in front of the so-called trade zone which extends from the big pier at Chikko, in Osaka, to the mouth of the Shirinashi-gawa has been submitted to the Osaka Municipal Assembly. The *Osaka Mainichi* states that the newly designed piers are to be something like islands, quite apart from the shore. Each is to be 200 ken long, while one will have a width of 55 ken, and the other a width of 77 ken. Enough quay space is to be provided for two 6,000-ton steamers to be moored alongside at one time. The piers are to be connected with the shore by swinging bridges. The sea near the piers is to be dredged to a depth of between 29 ft. and 33 ft. The total cost of this new work is estimated to be about 6,000,000 yen. When these structures are completed it will be possible to handle 900,000 tons of merchandise at Chikko. In addition, a Bill to extend the railway to Chikko has been presented. This provides for an outlay of 2,200,000 yen. The work is to be completed in six years, and it is hoped to commence work next year. (1 ken = 5.9 ft.; 1 yen = 2s. 0½d.)

SILICA BRICKS.—In presenting to the summer meeting of the American Association for Testing Materials papers on "Suggested Improvements in the Manufacture of Silica Bricks" and on "Slag Tests for Refractory Bricks," Messrs. C. E. Nesbitt and M. L. Bell (*Metallurgical and Chemical Engineering*, August 15, 1917) gave diverse practical hints and also described some experiments on the suitable fineness of material and on the influence of pressure. Their specimens consisted of a ganister (quartzite rock) ground to pass a 12-mesh, 8-mesh or 4-mesh screen, mixed with 9 per cent. of moisture and 2 per cent. of lime, and were made in a small hydraulic press at pressures ranging, in eight steps, from 187 lb. up to 2,500 lb. per square inch. The experiments showed the usual difficulty of combining desired properties. The strength was a little, but not much, increased by increase of pressure; the fine mesh bricks gave the highest values in the impact tests, but they showed also the greatest spalling loss. On the whole the 4-mesh material pressed at 1,500 lb. per square inch gave the most satisfactory results, the resulting bricks being strong, free from moulding defects, and suffering not more than the average loss from squatting. Attention should be paid to proper inspection during the various stages of the brick manufacture, and the consumer should have facilities for inspecting the bricks before they are loaded on the car.

CATALOGUES.

Electric Switch Systems.—The British Westinghouse Company, Limited, Trafford Park, Manchester, send 10 quarto pages of illustrations of large switchboard arrangements which they have fitted up for railway companies and large factories. The catalogue does not deal with details, but merely gives general views of recent construction, which will be helpful to those considering such work.

Electric Motors for Hoisting Work.—A range of 10 electric motors, from 2 h.p. to 50 h.p., specially for the intermittent work of hoists and cranes, is shown in a catalogue received from the British Thomson-Houston Company, Limited, Rugby. All are reversible, four-pole, series-wound, fitted with commutating poles and totally enclosed. Magnetic, disc or shoe brakes and back gears up to 5 to 1 reduction are fitted as required. In this catalogue very full particulars are given of all the chief dimensions, with the speed, horse-power and weight.

Second-Hand Machinery.—A catalogue, of about 200 pages, of second-hand machinery comes from Messrs. Thomas W. Ward, Limited, Albion Works, Sheffield. It is closely printed and occasionally illustrated, so that it includes about a thousand items, comprising engines, boilers, motors, pumps, tanks, wagons, general industrial machinery and machine tools, besides a certain amount of new material. The sizes, condition, &c., of the lots are stated and where each can be seen—the bulk at Sheffield, and some at the company's depots at Silvertown, Swansea, Wishaw and other places.

Hand-Drilling and Grinding Machines.—The Light Electric Motor Company, 15, Baltic-street, Dundee, send catalogues of portable drilling machines for hand use with electric drive. One series is made in four sizes from $\frac{7}{16}$ in. to $\frac{3}{4}$ in., each size geared or ungeared, and for direct or alternating current. The $\frac{3}{4}$-in. size weighs 13 lb. ungeared and 14½ lb. geared, the respective speeds being 500 r.p.m. and 300 r.p.m. The second series is sized by eighths, from $\frac{3}{8}$ in. to $\frac{7}{8}$ in., for direct current only, and up to 250 volts. There is also a side spindle make for heavier work. The grinding and polishing hand machine takes wheels up to 9 in. diameter, and may be connected an ordinary lighting circuit.

Refuse Destructor.—A series of destructors for burning waste and refuse are described in a catalogue issued by Messrs. Meldrums, Limited, Timperley, near Manchester. There are five stock sizes, to burn from 30 lb. to 100 lb. per hour, but special construction to suit the kind of waste to be dealt with is advised in cases where the quantities are considerable. Below 1 cwt. or 2 cwt. per day the furnace may be used for heating water, and for larger quantities steam boilers may be connected. Large installations have been successful in dealing with coal dust, cotton waste, sawdust, spent tan, and similar refuse, generating considerable supplies of steam. These inventions command attention when coal is dear and transport facilities are limited.

Coal Gas for Motor Cars.—The British Commercial Gas Association, 47, Victoria-street, London, S.W. 1, has issued a report giving information about the use of coal gas in petrol engines. Compressed gas in steel bottles may be regarded as impracticable at present, except under special conditions. The gas bags successfully used hold from 100 cub. ft. to 500 cub. ft. of coal gas at slightly over atmospheric pressure. They are made of rubber-covered canvas, and can be filled at any gas connection without special machinery. The engine gives, with coal-gas fuel, about 85 per cent. of its petrol fuel efficiency. 250 cub. ft. to 300 cub. ft. of coal gas may be taken as equal in fuel value to one gallon of petrol. These figures can only be given as rough approximations, and the system will leave a good deal of scope for skill in devising suitable fittings and in careful engine operation. The possible economy in cost is very considerable.

Tram-Car Brake.—Mr. C. J. Spencer, general manager, and Mr. J. W. Dawson, engineer to the Bradford City Tramways, valiantly undertook the task of inventing the "ideal brake equipment" as defined by the special committee of experts formed in consequence of Colonel York's drastic criticism of tramway brakes, in his report on the runaway accident at Highgate some years ago. The invention, after exhaustive and successful trials in Bradford (a town whose inclinations require the best possible brakes), is now described in a catalogue issued by the makers, Messrs. Coles, Marchent and Morley, Limited, Wakefield-road, Bradford. One brake serves all purposes—occasional, coasting and emergency. It may be put on by either driver or conductor, but can be taken off by the driver only. It is operated from pillars, one at each end of the car, by moving a small lever through four notches, which indicate the off position and three successive degrees of application. The brakes are four shoes which press straight down on the track and four more shoes which press upon the wheels, the track brakes always coming first into operation and last off, while the wheel brakes are only used in the maximum of emergency. The power used is compressed oil, with an air cushion in the storage cylinder, the compression being effected by a pump worked from the car axle. Normally the brakes are full on under the pressure of springs, and power is used to take off the brakes, so that in the event of defect or accident the brakes automatically come into operation. The whole mechanism is a most interesting example of the application of well-tried mechanical principles to the normal operation of the car and to the emergency operation successively; that is, an emergency is met by a little further movement of the lever that is always in use, and not by some special action which is rarely called for.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

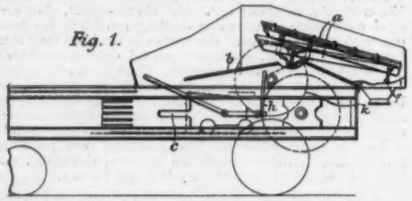
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

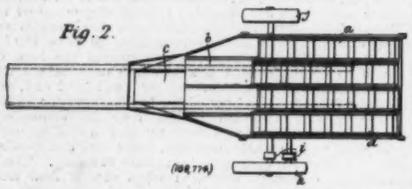
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

AGRICULTURAL APPLIANCES.

108,774. F. H. Livens, and G. C. Kirby, Lincoln. Hay and Straw Presses. (2 *Figs.*) October 18, 1916.—This invention relates to baling presses for hay and straw, of what is known as the perpetual type, wherein the material is fed into a rectangular chamber in which a reciprocating ram compresses the material into bales, which are forced through and removed at the opposite end of the chamber. In carrying the invention into effect, shakers *a* are arranged above the feeding table *b* of the hopper *c*, and consist of a series of long boxes with their tops formed by cross laths *d*, such as are used in thrashing machines, and preferably armed with curved tines or forks. Four such shaker elements are illustrated. Each element is supported at one end upon an oscillating link *f* pivoted on or swung from the machine frame, and at the other and high end is carried by an





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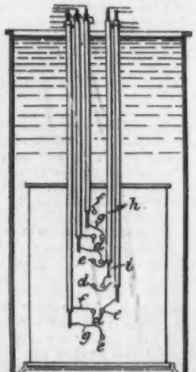
eccentric or crank, the cranks of the several shakers being formed on one shaft at such angles apart as to balance the shakers when they are rotated as far as possible. Motion is imparted to the cranks from any suitable source of power through a pulley *h*, either directly or otherwise, and belt transmission gearing *i* fitted with a flywheel *j*. The effect of this arrangement is that the masses of hay delivered on to the receiving ends of the shakers are given a progressively increasing tossing motion until they fall from the delivery ends of the shakers on to the feed board, from which they are pushed by other forks *h*, following the path indicated, into the hopper of the press, where the packing plunger operates in the usual manner. By the tossing motion described the masses are so loosened and broken up that they can be fed evenly into the hopper. (*Accepted August* 29, 1917.)

ELECTRICAL APPARATUS.

108,727. The British Electric Transformer Company, Limited, and S. C. Mount, Hayes, Middlesex. Electric Transformers. (6 *Figs.*) August 10, 1916.—This invention has reference to electric transformers of the static type, the secondaries of which are designed to have produced therein currents of very high value, such as are used in electric furnaces and electric welders. The invention has for object to provide



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terminal means for leading out heavy electric currents from the secondary windings of transformers of the kind referred to. For this purpose, in a transformer according thereto, the ends *d*, *e* of each coil or section of the secondary winding, or it may be of two or more of such coils or sections, are suitably connected as by flexible lengths of conductor *f*, *g* to two elongated terminal conductors *h*, *i* arranged one inside the other and separated by insulating material only, the inner conductor being preferably made tubular like the outer one. The inner conductor *i* projects at each end through the corresponding end of the outer tube *h*, so that both it and the outer tube can be readily connected to one or more of the secondary coils and to external transmission leads. The several pairs of terminal tubes from the secondary coils may conveniently be arranged to extend upwardly and parallel to one another at one side of the transformer. (*Accepted August* 29, 1917.)

108,795. W. E. Bradshaw, Holloway, London, and Callender's Cable and Construction Company, Limited, London. Electric Fuses. (2 *Figs.*) December 9, 1916.—This invention has special reference to fuses required in connection with testing electric circuits. The object of this invention is to provide a testing fuse which can be inserted in series in a circuit whereby the electrical conditions may be tested and so arranged that it will blow under short circuit conditions without causing material damage or personal risk to the operator. *a* is a fuse wire encased with asbestos and surrounded with a rigid tube *b* of insulating material provided at each end with metal caps. The tube *b* is mounted on an insulating handle *c*, provided with contacts *d* which engage with slotted fittings *f*, which, at

Fig. 1.

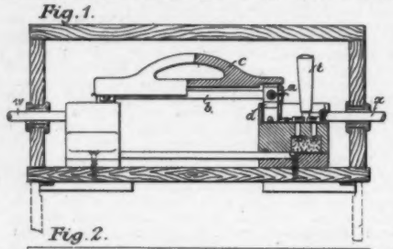
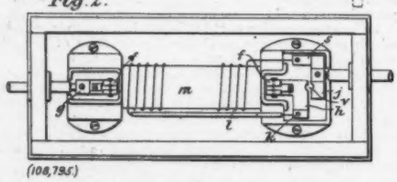


Fig. 2.



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one end of the box, form part of the terminal *g*, and on the other end of the box form part of a separate fitting *h*, separated from the cable terminal fitting *j*, and permitting a connection at *k* to a combined resistance and choking coil *l* connected electrically in series with the fuse and wound round an iron core *m*, bases *n* of ebonite, porcelain or other suitable material being secured to the bottom of the box *p* by screws *r*. The coil *l* is connected from the terminal *k* to terminal *s* and fitting *j*, and it will be seen therefore that when the plug handle *t* is inserted in the circular contact hole *v*, current from incoming cable *w* to outgoing cable *x* passes through the fuse *a* only, the choking coil *l* being shunted, but when the plug *t* is removed, then the current passes through the fuse *a* and the choking coil *l* in series. (*Accepted August* 29, 1917.)

108,831. Taylor, Tunnicliff and Co., Limited, Hanley, Staffordshire, and P. Cooper, Shelton, Stoke-on-Trent. Telegraph Insulators. (6 *Figs.*) March 16, 1917.—This invention relates to appliances for the shaping of the interiors and lower ends of telegraph insulators. According to the invention, the series of tools for the different operations are carried upon, and successively brought into use, by a longitudinally traversing turret-head 1, of any known or suitable construction. The tools carried upon the turret-head 1 comprise

Fig. 1.

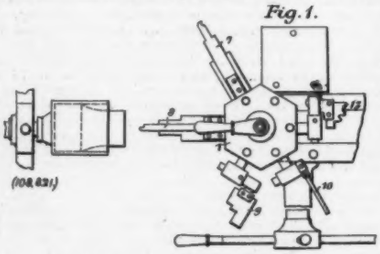

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Fig. 2.

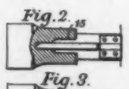


Fig. 4.

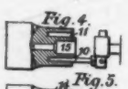


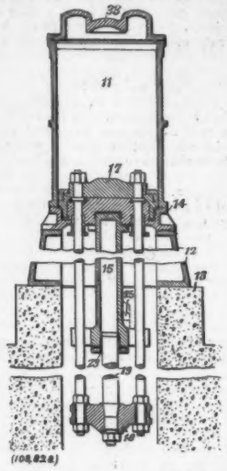
Fig. 3.

Fig. 5.

a shouldered roughing tool 7 for the central recess 15 of the insulator (see Fig. 2), a similar finishing tool 8 for the said recess being of the exact contour required; an eccentrically-fixed stepped tool 9 for determining the lengths of the inner and outer petticoats; an eccentrically-fixed grooving tool 10 for producing the annular recess 11 between the inner and outer petticoats, and an eccentrically-fixed finishing tool 12 for simultaneously shaping the ends of both inner and outer petticoats 13, 14. (*Accepted August* 29, 1917.)

HYDRAULIC MACHINERY.

108,828. Davy Brothers, Limited, and T. W. Hand, Sheffield, Yorkshire. Steam Hydraulic Intensifiers. (2 *Figs.*) April 12, 1917.—The steam cylinder 11 of the intensifier is mounted, with its axis vertical, upon a stool 12, which rests upon the foundation 13, the bottom cover 14 of the steam cylinder being interposed as a distance-piece between the cylinder and the stool. The hydraulic cylinder 15, which depends beneath the steam cylinder 11, is provided at its upper end with a flange, by means of which it is bolted to the underside of the bottom cover 14 of the steam cylinder, the two cylinders 11 and 15 extending in axial alignment with one another. The steam piston 17 (which is shown as occupying its lowest position) is coupled to a crosshead 18 on the lower end of the hydraulic ram 19 (also shown in its lowest position), by means of a pair of side rods which pass through stuffing-boxes in the cover 14 and extend on opposite sides of and parallel to the common axis of the cylinders 11 and 15; the rods passing through guides on the lower end of the hydraulic cylinder 15. The ram 19 passes through a hydraulic stuffing-box 23 at the lower end of the cylinder 15. A plate of insulating material is interposed between the flange of the hydraulic cylinder 15 and the bottom cover 14 of the steam cylinder 11, and hence, as the rods 20 are exposed to the atmosphere throughout the greater part of their length, whilst the hydraulic cylinder 15 is exposed to the atmosphere permanently throughout its whole length, and the ram 19 is also



(108,828.)

exposed when at its lowest position, very little heat is able to pass by conduction from the steam cylinder to the hydraulic packing 23. The hydraulic main-pressure pipe (not shown) is connected with an opening 25 in the side of the cylinder 15, near its lower end, at such a level as to be adapted to extend directly beneath the ground to the immediate vicinity of the press. The top cover 33 of the steam cylinder 11 is made removable, so as to allow the ready access to the piston packing, which is preferably held in place by means of a junk ring attached from above to the piston. The steam-pipe connection (not shown) for both supply and exhaust can be led in through the bottom cover 14, and hence the steam cylinder 11 can, when required, be lifted off the cover 14 without disturbing the latter or the piston 17, or any of the parts connected with either of these. (*Accepted August* 29, 1917.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

108,792. J. Farrar and E. A. Malkin, Halifax, Yorkshire, and A. R. Whitehead, Leeds, Yorkshire. Clutches. (3 *Figs.*) December 6, 1916.—This invention relates to friction clutches for transmitting power from one shaft to another. A is the driven portion of the clutch, B the driving portion, C the expanding ring, and D the sliding member. The portion A is formed with a drum *a* for the reception of the expanding ring C, the outer surface of the drum serving as a pulley or sprocket wheel. The drum is formed with a boss a^1, which is bored to take a sleeve a^2, flanged at each end, the flanges fitting the bore of the boss a^1. The flanges cause an enclosed annular space a^4 to exist between the sleeve a^2 and the boss a^1 for the reception of lubricant. The sleeve has a hole drilled longitudinally through its wall, so near to the inner surface of the sleeve as to break through it. Extending through the outer surface of the sleeve to the longitudinal hole or passage is a number of holes a^3. After the sleeve has been constructed in the manner described, a length of cotton wick a^9 is inserted in the longitudinal hole or passage. The

Fig. 1.

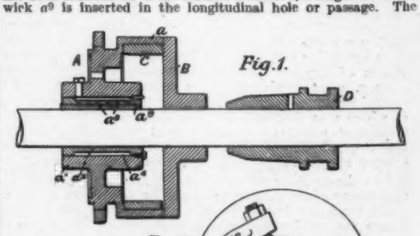
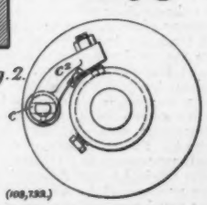


Fig. 2.



(108,792.)

wick a^9 runs in contact with the shaft, and conveys the lubricant thereto. The expanding ring C normally fits loosely within the drum *a*, and may be of the usual construction and be expanded by the usual block *c*. This block is rigidly fixed on a spindle c^1, passing freely through a boss on the driving portion B that is rigidly fixed on the shaft, and closes the open face of the drum A. Rigidly fixed on the outer end of the spindle is an arm c^2 carrying a set screw c^3, that is adapted to be engaged by the sliding member D, to turn the block *c* to expand the internal split ring C. To prevent slip, which is liable to take place between the sliding member D and set screw, unless the latter is accurately adjusted, and which becomes aggravated owing to wear, the sliding member is slightly tapered, instead of being cylindrical in accordance with the usual practice, and the set screw is adjusted so that it will expand the ring C immediately the smaller portion of the slightly tapered part comes underneath the screw, the said taper being so slight as to preclude any appreciable end-thrust being exerted upon the sleeve by its contact with the screw. (*Accepted August* 29, 1917.)